FILE COPY

Prepared by
Oak Ridge Associated
Universities

Prepared for
Division of
Remedial Action
Projects

U.S. Department
of Energy

COMPREHENSIVE RADIOLOGICAL SURVEY

OFF-SITE PROPERTY V

NIAGARA FALLS STORAGE SITE

LEWISTON, NEW YORK

A. J. BOERNER

Radiological Site Assessment Program
Manpower Education, Research, and Training Division

FINAL REPORT

April 1984

COMPREHENSIVE RADIOLOGICAL SURVEY

OFF-SITE PROPERTY V
NIAGARA FALLS STORAGE SITE
LEWISTON, NEW YORK

Prepared for

U.S. Department of Energy
as part of the
Formerly Utilized Sites -- Remedial Action Program

A. J. Boerner

Project Staff

J.D. Berger	W.L. Smith*
J. Burden*	T.J. Sowell
R.D. Condra	M.W. Stafford
J.S. Epler*	G.M. Stephens
P.W. Frame	L.B. Taub*
W.O. Helton	C.F. Weaver
J.M. Mahathey*	B.S. Zacharek
J.A. Perry	

Prepared by

Radiological Site Assessment Program
Manpower Education, Research, and Training Division
Oak Ridge Associated Universities

FINAL REPORT

April 1984

This report is based on work performed under contract number DE-AC05-76OR00033 with the Department of Energy.

* Evaluation Research Corporation, Oak Ridge, Tennessee.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

COMPREHENSIVE RADIOLOGICAL SURVEY

OFF-SITE PROPERTY V
NIAGARA FALLS STORAGE SITE
LEWISTON, NEW YORK

INTRODUCTION

Beginning in 1944, the Manhattan Engineer District and its successor, the Atomic Energy Commission (AEC), used portions of the Lake Ontario Ordnance Works (now known as the Niagara Falls Storage Site (NFSS) and associated off-site properties) approximately 3 km northeast of Lewiston, New York, for storage of radioactive wastes. These wastes were primarily residues from uranium processing operations; however, they also included: contaminated rubble and scrap from decommissioning activities, biological and miscellaneous wastes from the University of Rochester, and low-level fission-product waste from contaminated-liquid evaporators at the Knolls Atomic Power Laboratory (KAPL). Receipt of radioactive waste was discontinued in 1954, and following cleanup activities by Hooker Chemical Co., 525 hectares of the original 612-hectare site were declared surplus. This property was eventually sold by the General Services Administration to various private, commercial, and governmental agencies.[1]

Somerset Group, Inc. is the current owner of a tract identified as off-site property V (see Figure 1). A radiological survey of that tract, conducted in June through August 1983, is the subject of this report.

SITE DESCRIPTION

Figure 2 is a plot plan of off-site property V. This property is rectangular in shape and measures approximately 360 m long by 310 m wide; it occupies an area of 11 hectares. The site is bounded by Balmer Road on the north and "H" Street on the south. Property V originally extended eastward to Castle Garden Road; however the eastern portion is currently owned by SCA Chemical Services and that portion was surveyed as part of off-site property A. Security fencing presently delineates the eastern property boundary, as well as the western boundary; fencing also parallels Balmer Road near the northern perimeter.

There are several interior roads including Wesson Road and "5" Street. Major drainage ditches are parallel to and outside the east, west, and north security fences; smaller ditches are located throughout the property. The major ditch to the west of the property is the Central Drainage Ditch – the major surface drainage route for the Niagara Falls Storage Site. There are five buildings on the site (one of these buildings is partially on adjacent property U). Numerous foundations and slabs remain from previous structures. The land is generally level, with the exception of a large mound of topsoil in the north-central section of the property. Some dense brush and trees occupy the northeast corner; otherwise the site is relatively clear and portions are maintained.

Radiological History

There is no history indicating burials of contaminated material on property V; however, residues may have been temporarily stored along "H" Street near its intersection with "5" Street.[1] Because of construction activities associated with the Mathieson rocket fuel facilities, it is likely that any surface contamination from earlier MED/AEC operations would have been disturbed and/or relocated. The 1971-72 AEC survey identified elevated gamma radiation levels along Wesson Road and east of the intersection of "5" Street with an unnamed east/west road.[2] The 1980 mobile scan by ORNL confirmed these findings.[3] Previous surveys also identified contamination of the adjacent Central Drainage Ditch, resulting in elevated direct radiation levels in its vicinity.[2,3]

SURVEY PROCEDURES

The comprehensive survey of NFSS off-site property V was performed by the Radiological Site Assessment Program of Oak Ridge Associated Universities (ORAU), during June-August 1983. The survey was in accordance with a plan dated March 18, 1983, approved by the Department of Energy. The objective and procedures from that plan are presented in this section.

Objective

The objective of the survey was to provide a comprehensive assessment of the radiological conditions on property V. Radiological information collected included:

1. direct radiation exposure rates and surface beta-gamma dose rates,
2. locations of contaminated surface areas,
3. concentrations of radionuclides in surface and subsurface soil,
4. concentrations of radionuclides in surface and ground water, and
5. contamination levels on interior building surfaces.

Procedures

1. Brush and weeds were cleared as needed to provide access for gridding and surveying and a 20 m grid system was established by McIntosh and McIntosh of Lockport, NY, under subcontract. The grid system is shown on Figure 3.

2. Walkover surface scans were conducted over all accessible areas of the property. Traverses were at 2-5 m intervals on those areas that were relatively inaccessible and had no history of radioactive use. Scanning intervals were 1-2 m along all roads, in areas previously identified as having elevated radiation levels, and in other areas where direct radiation measurements suggested possible contaminated residues. Portable gamma NaI(Tl) scintillation survey meters were used for the scans. Locations of elevated contact radiation levels were noted.

3. Gamma exposure rate measurements were made at the surface and at 1 m above the surface at 20 m grid intervals. Measurements were performed using portable gamma NaI(Tl) scintillation survey meters. Conversion of these measurements to exposure rates in microroentgens per hour (μR/h) was in accordance with cross calibration with a pressurized ionization chamber.

4. Beta-gamma dose rate measurements were performed 1 cm above the surface at 20 m grid intervals. These measurements were conducted using thin-window (<7 mg/cm^2) G-M detectors and portable scaler/ratemeters. Measurements were also obtained with the detector shielded to evaluate contributions of nonpenetrating beta and low-energy gamma radiations. Meter readings were converted to dose rates in microrads per hour (µrad/h) based on cross calibration with a thin-window ionization chamber.

5. Surface (0-15 cm) soil samples of approximately 1 kg each were collected at 20 m grid intervals.

6. At selected locations of elevated surface radiation levels, beta-gamma dose rates at 1 cm above the surface and exposure rates at 1 m above the surface were also measured. Surface samples were obtained from these locations and, following sampling, surface exposure rates were remeasured for comparison with presampling levels.

7. Detection Sciences Group of Carlisle, MA, performed ground penetrating radar surveys at proposed borehole locations to assure that subsurface piping and utilities were not damaged during drilling. In some cases, boreholes were relocated slightly.

8. Boreholes were drilled to provide a mechanism for logging subsurface direct radiation profiles and collecting subsurface soil and water samples. Fourteen boreholes were drilled by Site Engineers, Inc., of Cherry Hill, NJ, using truck mounted 20 cm diameter hollow-stem augers. The locations of these boreholes are shown on Figure 4.

   Gamma radiation scans were performed in the boreholes to identify the locations of elevated direct radiation levels which might indicate subsurface residues. Radiation profiles in the boreholes were determined by measuring gamma radiation at 15-30 cm intervals between the surface and ground water or the hole bottom. A collimated gamma scintillation detector and portable scaler were used for these measurements.

Ground water samples of approximately 3.5 liters were collected from nine borehole locations using a hand bailer. Soil samples of approximately 1 kg each were collected from various depths in selected holes by scraping the sides of each borehole with an ORAU designed sampling tool.

9. Two water samples were collected from areas of standing (surface) water (see Figure 5).

10. Gamma scans and exploratory measurements of direct alpha and beta-gamma levels were performed in existing buildings. On the basis of the negative results of these measurements, further surveying of interior building surfaces was not performed.

11. Twenty soil samples and seven water samples were collected from the Lewiston area (but not on NFSS or associated off-site properties) to provide baseline concentrations of radionuclides for comparison purposes. Direct background radiation levels were measured at locations where baseline soil samples were collected. The locations of the baseline samples and background measurements are shown on Figure 6.

Sample Analyses and Interpretation of Results

Soil samples were analyzed by gamma spectrometry. Radium-226 was the major radionuclide of concern, although spectra were reviewed for U-235, U-238, Th-232, Cs-137, and other gamma emitters. Water samples were analyzed for gross alpha and gross beta concentrations.

Additional information concerning analytical equipment and procedures is in Appendix A.

Results of this survey were compared to the applicable guidelines for formerly utilized radioactive materials handling sites, which are presented in Appendix B.

RESULTS

Background Levels and Baseline Concentrations

Background exposures rates and baseline radionuclide concentrations in soil, determined for 20 locations (Figure 6) in the vicinity of the NFSS, are presented in Table 1-A. Exposure rates ranged from 6.8 to 8.8 μR/h (typical levels for this area of New York). Concentrations of radionuclides in soil were: Ra-226, <0.09 to 1.22 pCi/g (picocuries per gram); U-235, <0.14 to 0.46 pCi/g; U-238, <2.20 to 6.26 pCi/g; Th-232, 0.32 to 1.18 pCi/g; and Cs-137, <0.02 to 1.05 pCi/g. These concentrations are typical of the radionuclide levels normally encountered in surface soils.

Radioactivity levels in baseline water samples are presented in Table 1-B. The gross alpha and gross beta concentrations ranged from 0.55 to 1.87 pCi/l (picocuries per liter) and <0.63 to 14.3 pCi/l, respectively. These are typical of concentrations normally occurring in surface water.

Direct Radiation Levels

Direct radiation levels, measured at 20 m grid intervals, are presented in Table 2. The gamma exposure rates at 1 m above the surface at these locations ranged from 4 to 20 μR/h (average 7 μR/h). Surface contact gamma exposure rates and beta-gamma dose rates were 5 to 29 μR/h (average 8 μR/h) and 5 to 69 μrad/h (average 14 μrad/h), respectively. At most locations, measurements performed with the detector shielded averaged approximately 20% less than those with the unshielded detector. This indicates only a small portion of the surface dose rate is due to nonpenetrating beta or low-energy photon radiations.

The walkover survey identified numerous small areas and isolated spots of elevated contact radiation levels. These locations are indicated on Figure 8 and associated radiation levels are presented in Table 3. Surface contact gamma exposure rates ranged from 12-240 μR/h; the maximum was measured at grid point 541N, 123E. Exposure rates at 1 m above the surface ranged from 13 to 26 μR/h. Beta-gamma dose rates ranged from 20-450 μrad/h. The maximum dose rate was also recorded at grid coordinate 541N, 123E. Contact exposure and beta-gamma dose rates were not reduced by soil sampling at many of these locations; the most notable example occurred at grid point 541N, 179E where the contact exposure rate increased from 220 to 1100 μR/hr following sampling.

Radionuclide Concentrations in Surface Soil

Table 4 lists the concentrations of radionuclides measured in surface soil from 20 m grid intervals. These samples contained Ra-226 concentrations ranging from <0.14 to 3.54 pCi/g. The highest level was in the sample collected at grid point 820N, 40W. The walkover surface scan identified this general area as having slightly elevated contact gamma readings. A few additional samples contained Ra-226 concentrations exceeding those in the baseline soil, but none exceeded 5 pCi/g above the baseline level. Three of these samples also contained U-238 concentrations slightly above baseline levels; the highest was 7.00 pCi/g in the samples from grid coordinates 600N, 50W and 580N, 60E. Slightly elevated concentrations of U-235, Th-232, and Cs-137 were also present in a few samples, but levels were generally comparable to the ranges in baseline soil. No other gamma emitting radionuclides were present at levels exceeding those normally occurring in soil.

Radionuclide concentrations in samples from locations of elevated contact radiation levels are presented in Table 5. Concentrations of Ra-226 in these samples ranged from 23.7 to 4,280 pCi/g; the maximum concentration was measured in a piece of rock-like material (sample B10) from grid point 541N, 179E. Sample B9 (541N,123E), also a large rock, contained 990 pCi/g of Ra-226 and elevated U-238 and Th-232 concentrations (94.8 and 84.5 pCi/g, respectively).

Samples B1-B8 contained Ra-226 levels between 20 and 50 pCi/g with comparable concentrations of U-238. These samples were all small rocks associated with construction fill or paving. Similar material has been noted on other NFSS properties and throughout the Niagara Falls area; the radionuclide levels in this particular type of rock is believed to be of natural origin and not the result of previous MED/AEC operations on this site.

Borehole Gamma-Logging Measurements

The results of gamma scintillation measurements in boreholes indicate elevated radionuclide levels to a depth of 30-60 cm in several areas. As evidenced by analyses of subsurface samples, the gamma borehole measurements were reliable indicators of elevated radionuclide levels. However, the gamma logging data was not useful in quantifying radionuclide concentrations in the subsurface soil, because of the varying ratios of Ra-226, U-235, U-238, Th-232, and Cs-137 occurring in soils from this site.

Radionuclide Concentrations in Borehole Soil Samples

Table 6 presents radionuclides measured in soil samples from boreholes. At borehole locations H1-H9, located to be representative of the general property conditions, logging measurements did not identify evidence of elevated subsurface radionuclide levels. Therefore, only samples of surface soil were collected at these locations.

Subsurface samples from boreholes H10, H12, and H13, drilled in areas of elevated direct surface radiation, contained concentrations of Ra-226 above the baseline soil levels. The highest concentration was 20.6 pCi/g, from the 15 cm depth in borehole H10. This sample also contained 39.1 pCi/g of U-238. The activity in this sample was associated with small pieces of rock; similar rock and radionuclide levels were noted in the surface sample from this location. In borehole H12 the Ra-226 levels were slightly elevated at the 90 cm depth; however the concentration was only 2.16 pCi/g. Samples from 30 cm and 120 cm deep in borehole H13 contained

12.3 and 3.65 pCi/g of Ra-226. The high direct radiation level measured at this location after surface sampling, and the borehole logging measurements indicate, however, that material (possibly individual rocks) containing radionuclide levels considerably greater than those observed in the subsurface sample, are present at approximately 30 cm deep in this area.

Radionuclide Concentrations in Water

Surface Water

Samples W1 and W2 from standing water on property V (refer to Table 7) contained gross alpha concentrations of 1.62 and 1.83 pCi/l, respectively. Gross beta concentrations of 2.77 pCi/l (W1) and 10.3 pCi/l (W2) were present. These values are within the range measured in baseline water samples.

Subsurface Water

Water samples collected from boreholes contained from 1.08 to 10.6 pCi/l of gross alpha and 1.15 to 14.7 pCi/l of gross beta. The alpha level is higher than those measured in baseline samples; however, both alpha and beta levels are within the EPA Drinking Water criteria. It should be noted that high concentrations of dissolved solids in many of these samples resulted in residues which adversely affected the relative errors of the analytical procedure.

Building Surveys

Results of the gamma scans and measurements and exploratory measurements of direct alpha and beta-gamma levels, performed in five buildings, are presented in Table 8. Gamma exposure rates at 1 m above the floor ranged from 4.2 to 6.7 μR/h. Beta-gamma dose rates ranged from 0.01-0.03 mrad/h. Total alpha contamination levels ranged from <26 to 103 d/m/100 cm^2; beta-gamma levels were all <394 d/m/100 cm^2 with the exception of an isolated area in one of the buildings where a surface beta-gamma measurement of 634 d/m/100 cm^2 was recorded.

COMPARISON OF SURVEY RESULTS WITH GUIDELINES

The guidelines applicable to cleanup of off-site properties at the Niagara Falls Storage Site are presented in Appendix B. Radiation levels and radionuclide concentrations at small, isolated spots of surface or near-surface contamination exceed these guideline values.

The exposure rates in contact with two of the isolated areas of surface contamination exceed the NRC guideline of 60 μR/h for open land areas accessible by the general public. The highest level measured (before sampling) was 240 μR/h at grid point 541N, 123E. At grid coordinate 541N, 179E contact exposure levels increased from 220 to 1100 μR/h following sampling. The average exposure rate of 7 μR/h at 1 m above the surface is well within the 60 μR/h guideline.

Concentrations of Ra-226 in excess of 5 pCi/g above the baseline level are present on the surface of the property. Most of these locations are associated with small areas of rock fill, which also contains equivalent concentrations of U-238. The radionuclide content is therefore believed to be of natural origin and not attributable to previous MED/AEC activities at this site. At several locations, Ra-226 levels exceeding 15 pCi/g were identified in subsurface rock fill. Isolated pieces of rock-like material with higher levels of Ra-226, but without comparable U-238 concentrations, were also noted. This material is considered to have resulted from MED/AEC activities. Direct surface and borehole logging measurements indicate subsurface deposits of this material to 30 cm deep at grid coordinate 541N, 179E. The total volume of this material is estimated to be less than 1 m^3 and the Ra-226 concentration averaged over 100 m^2 would be within the criteria.

Surface and subsurface water contained radionuclide concentrations below the EPA Interim Drinking Water Standards of 15 pCi/l, gross alpha, and 50 pCi/l, gross beta.

Exposure rates inside buildings are comparable to background levels. Alpha surface contamination levels are less than the criteria of 100 d/m/100 cm^2 average and 300 d/m/100 cm^2 maximum (based on Ra-226). Beta-gamma surface contamination levels were, with one exception, below detection limits.

SUMMARY

A comprehensive survey of off-site property V at the Niagara Falls Storage Site was conducted during June-August 1983. The survey included surface radiation scans, measurements of direct radiation levels, analyses for radionuclide concentrations in surface and subsurface soil and water samples, and measurements of contamination levels in buildings. Ground-penetrating radar was used to identify subsurface utilities, which might preclude borehole drilling.

The survey identified small isolated areas of elevated direct radiation and soil contamination. The major contaminant is Ra-226; however, U-238 and Th-232 are also present. Most of these areas are associated with rock material similar to that commonly used as a fill and paving base in the Niagara Falls area. It is believed to be of natural origin and not attributable to previous MED/AEC activities on this site. Several isolated pieces of rock-like material, containing primarily Ra-226 at higher concentrations than in the rock fill, were also located; this material is also similar to residues identified on other off-site properties.

Subsurface contamination was identified at 15-30 cm deep at two borehole locations.

Radionuclide concentrations in surface and subsurface water are within EPA Drinking Water Standards and contamination was not identified in buildings on the property.

Although the contaminated residues on small portions of this property exceed the guidelines established for release of the site for unrestricted use by the general public, the contaminants do not pose potential health risks to the public or site workers and are not migrating from the property.

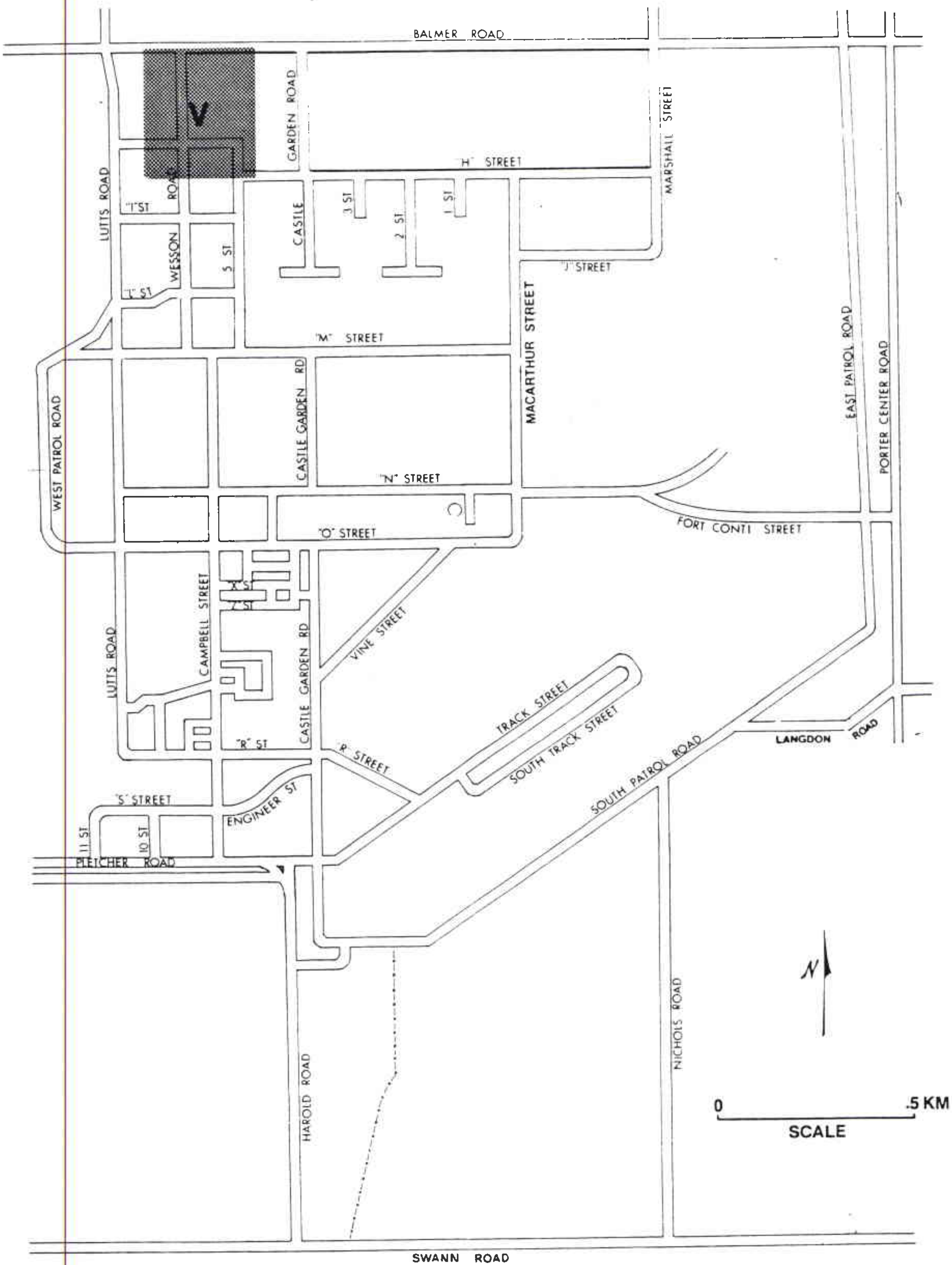

FIGURE 1. Map of Niagara Falls Storage Site and Off-Site Properties, Lewiston, New York, Indicating the Location of Off-Site Property V.

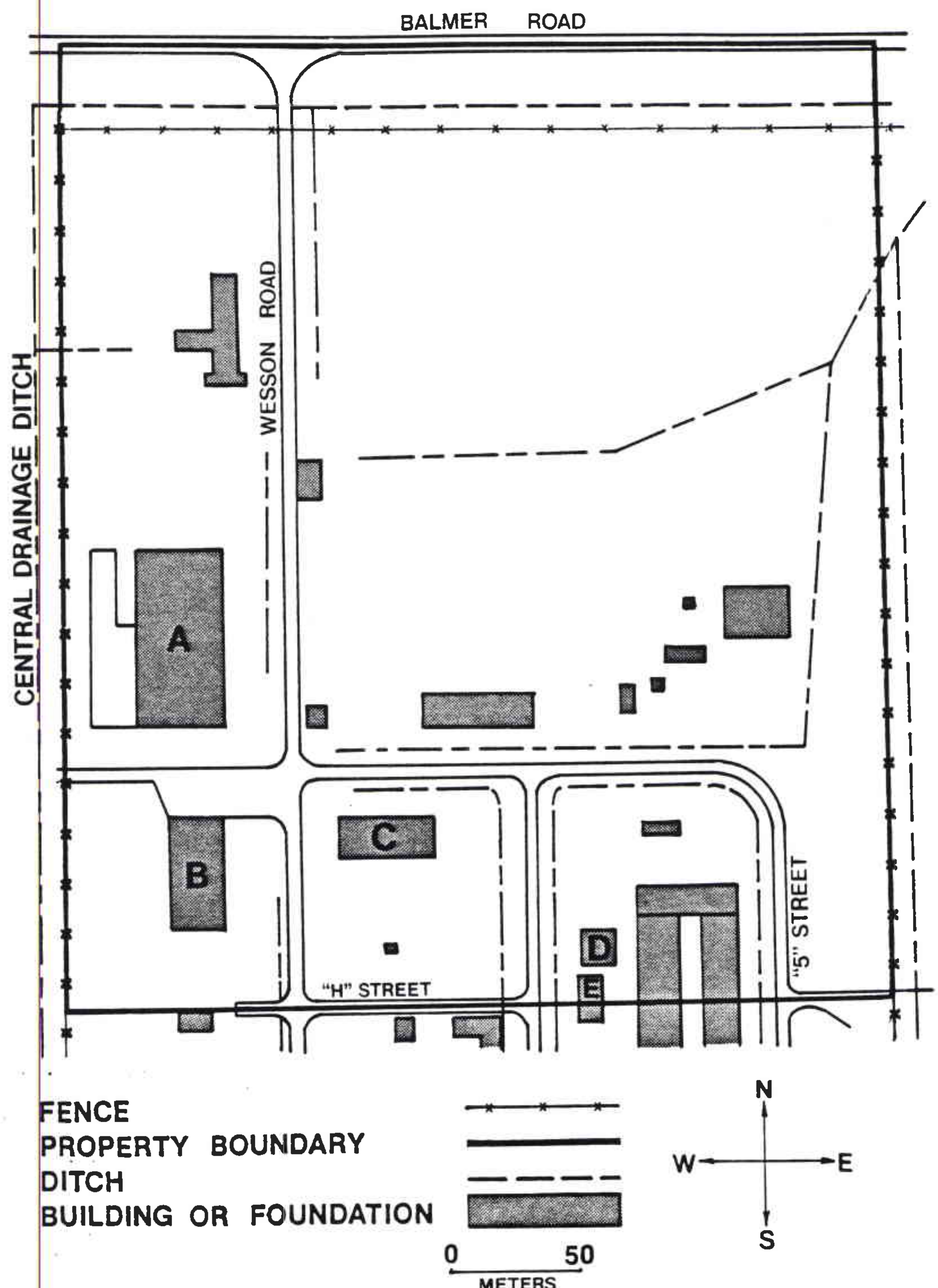

FIGURE 2. Plan View of NFSS Off-Site Property V Indicating Prominent Surface Features.

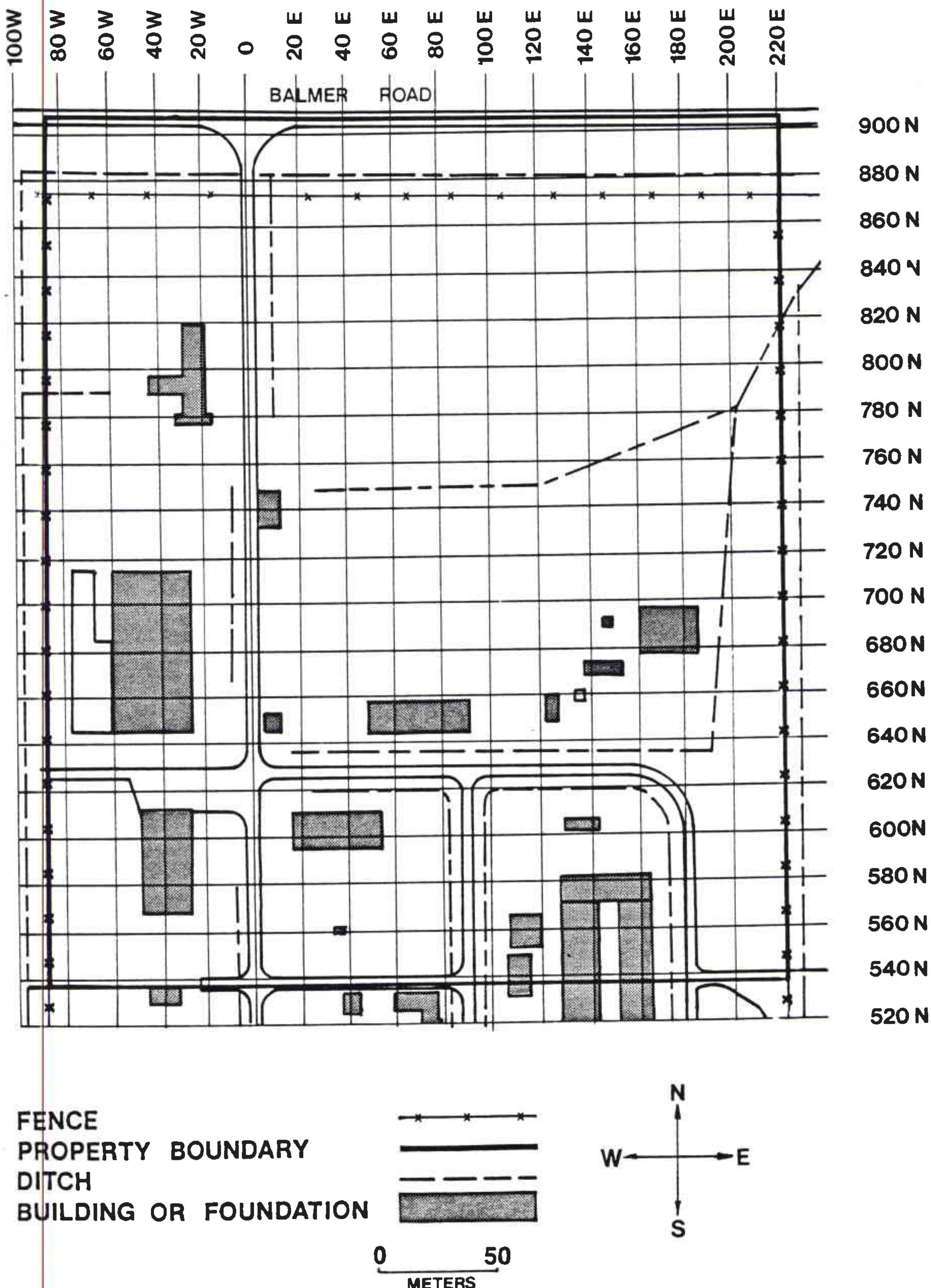

FIGURE 3. Plan View of NFSS Off-Site Property V Indicating the Grid System Established for Survey Reference.

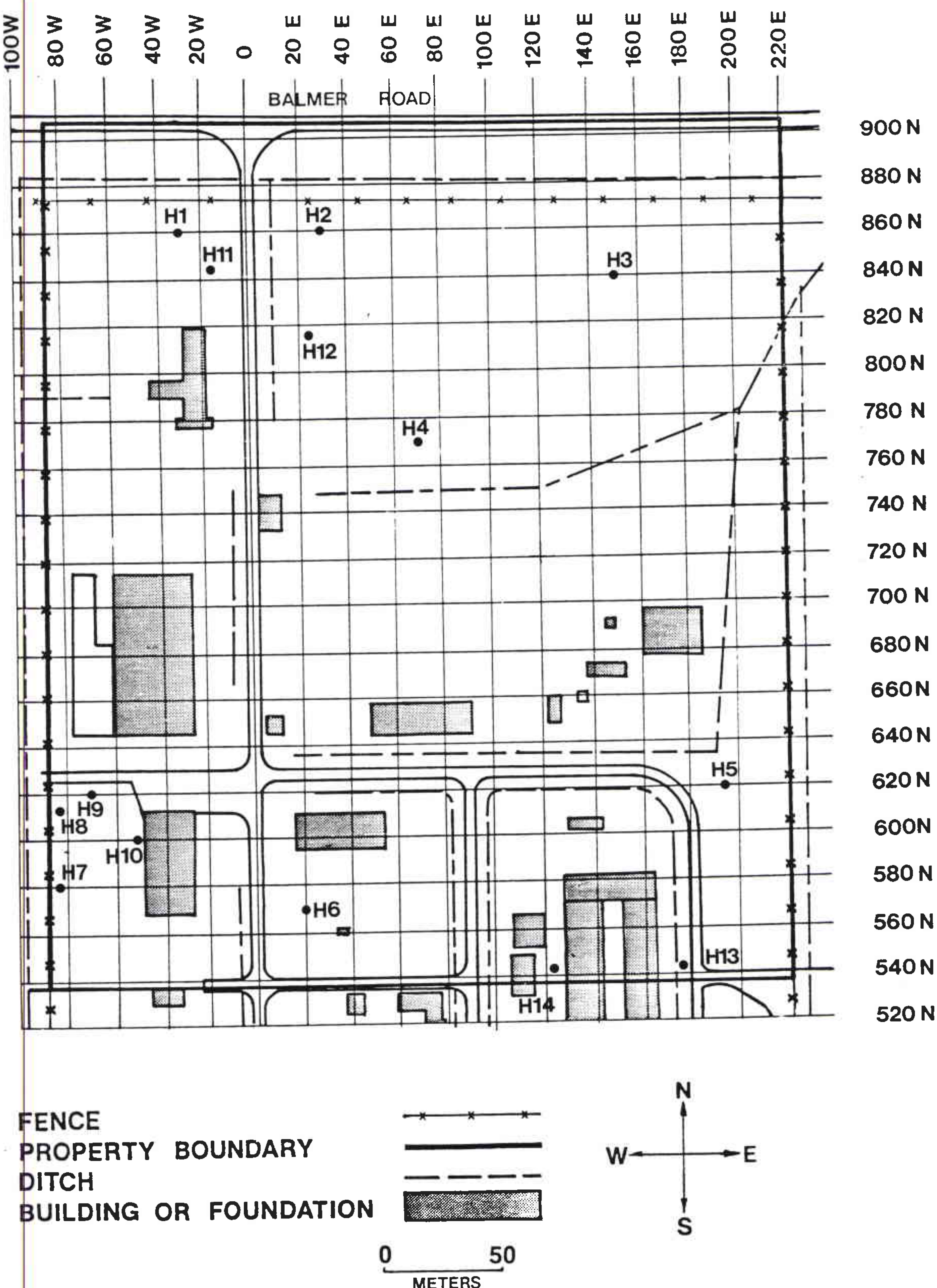

FIGURE 4. Locations of Boreholes for Subsurface Investigations.

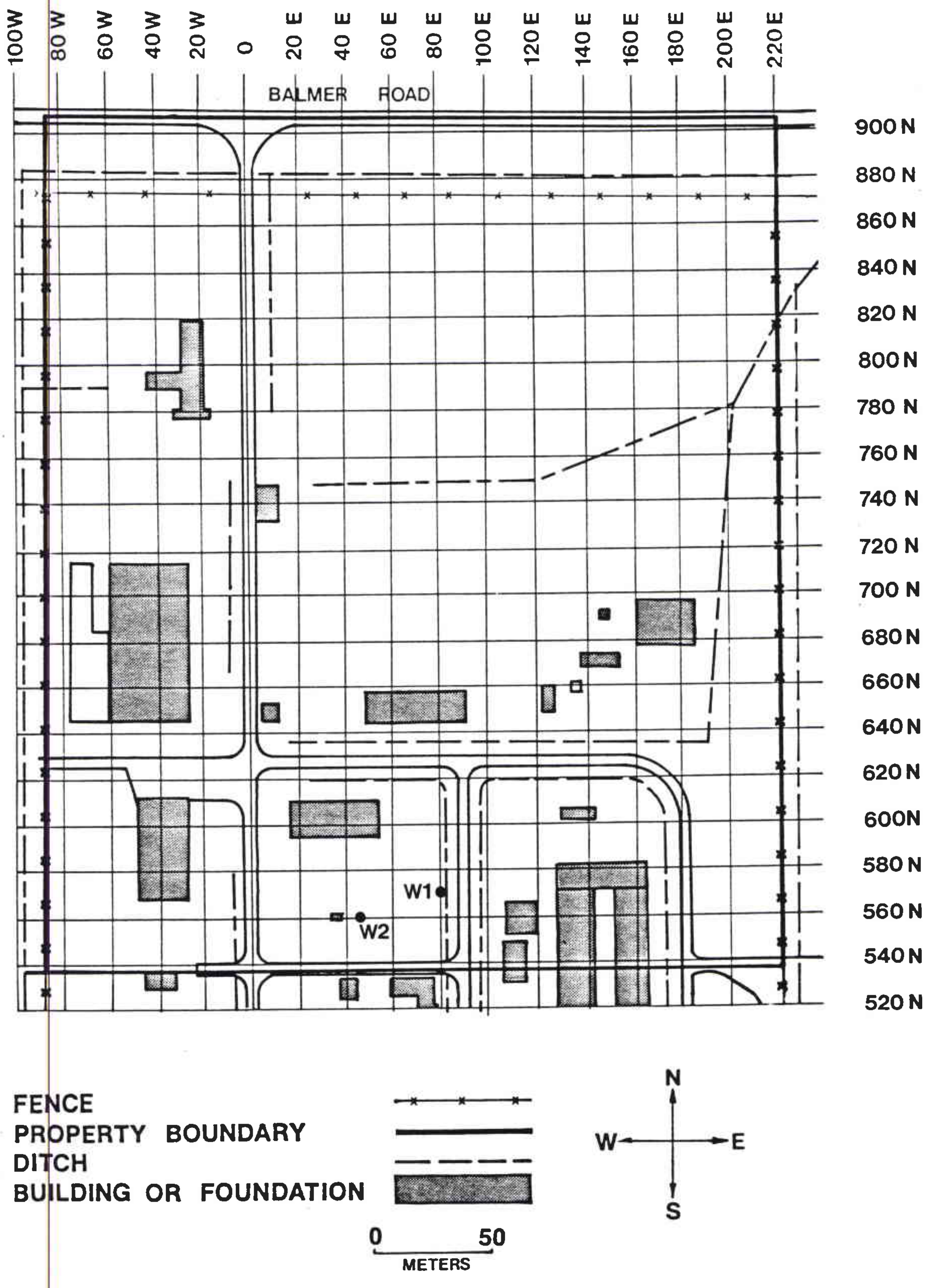

FIGURE 5. Locations of Water Samples from Standing Water.

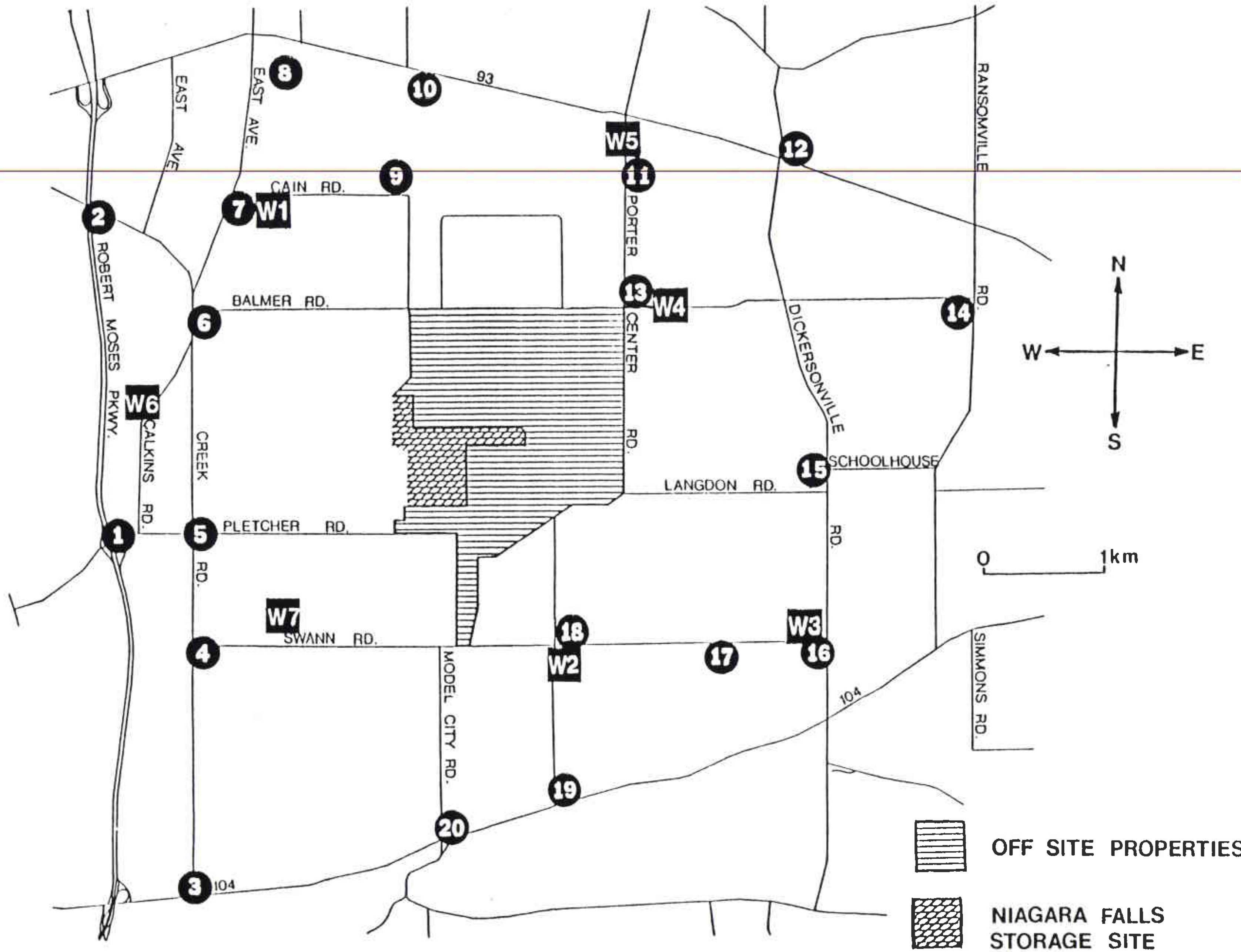

FIGURE 6. Map of Northern Niagara County, New York, Showing Locations of Background Measurements and Baseline Samples. (#1-20: soil samples and direct measurements; W1-W7: water samples.)

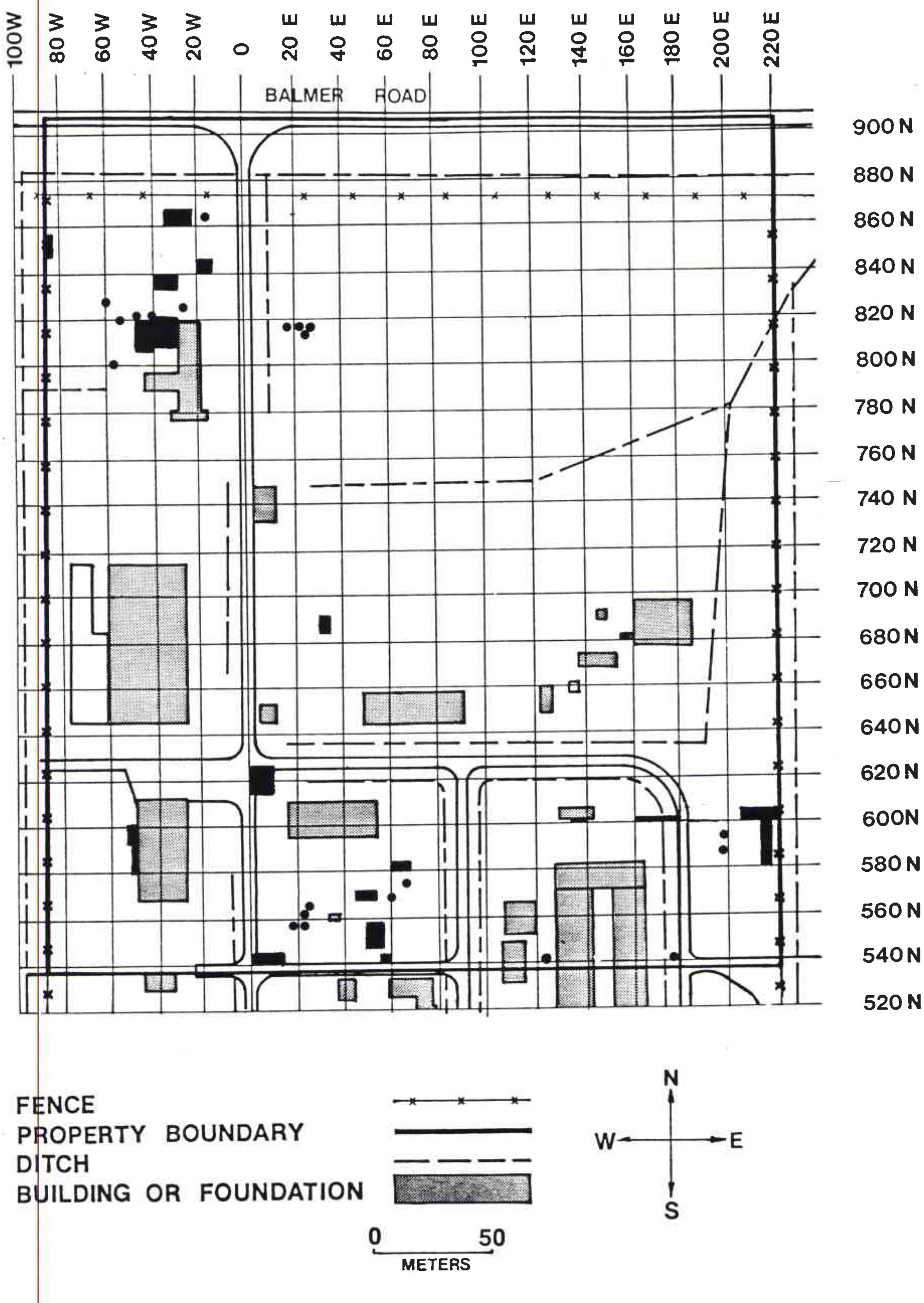

FIGURE 7. Map of NFSS Off-Site Property V Indicating Areas of Elevated Direct Radiation and Locations Where Radionuclide Concentrations in Soil Exceed Criteria.

TABLE 1-A

BACKGROUND EXPOSURE RATES
AND
RADIONUCLIDE CONCENTRATIONS IN BASELINE SOIL SAMPLES

Location [a]	Exposure Rate [b] (μR/h)	Radionuclide Concentrations (pCi/g)				
		Ra-226	U-235	U-238	Th-232	Cs-137
1	6.8	0.74 ± 0.16 [c]	<0.19	<2.89	0.70 ± 0.46	0.29 ± 0.08
2	6.8	0.75 ± 0.19	<0.19	<3.35	0.84 ± 0.24	0.24 ± 0.08
3	8.3	0.71 ± 0.18	0.46 ± 0.41	<3.72	0.88 ± 0.33	0.34 ± 0.09
4	7.9	0.67 ± 0.18	<0.22	<4.10	1.18 ± 0.35	0.12 ± 0.07
5	7.3	0.70 ± 0.16	<0.17	<3.34	0.68 ± 0.24	0.14 ± 0.07
6	7.7	0.50 ± 0.15	<0.16	<2.33	0.52 ± 0.38	0.17 ± 0.09
7	7.7	0.63 ± 0.13	<0.17	<2.73	0.83 ± 0.24	0.35 ± 0.08
8	7.6	0.59 ± 0.12	<0.14	<2.20	0.54 ± 0.23	<0.02
9	7.1	0.63 ± 0.20	<0.23	<4.16	0.83 ± 0.38	0.69 ± 0.11
10	7.1	0.70 ± 0.16	<0.19	<2.98	0.59 ± 0.25	0.69 ± 0.10
11	6.7	<0.09	<0.19	<2.83	0.49 ± 0.31	0.48 ± 0.14
12	7.1	0.48 ± 0.13	<0.16	<2.84	0.65 ± 0.26	0.68 ± 0.10
13	6.7	0.57 ± 0.14	<0.17	<2.36	0.49 ± 0.26	0.41 ± 0.08
14	6.8	0.68 ± 0.17	<0.19	<3.24	0.67 ± 0.25	0.70 ± 0.10
15	8.2	0.65 ± 0.14	<0.17	<3.20	0.72 ± 0.35	0.23 ± 0.08
16	7.4	0.91 ± 0.17	<0.71	<3.58	0.83 ± 0.28	0.61 ± 0.09
17	7.0	0.48 ± 0.14	<0.16	<2.73	0.32 ± 0.22	0.38 ± 0.08
18	7.7	0.73 ± 0.16	<0.18	6.26 ± 9.23	1.01 ± 0.44	0.32 ± 0.12
19	8.8	1.22 ± 0.22	<0.23	<3.79	1.08 ± 0.49	1.05 ± 0.13
20	8.6	0.83 ± 0.17	<0.21	<3.59	0.84 ± 0.29	0.08 ± 0.07
Range	6.8 to 8.8	<0.09 to 1.22	<0.14 to 0.46	<2.20 to 6.26	0.32 to 1.18	<0.02 to 1.05

[a] Refer to Figure 6.
[b] Measured at 1 m above the surface.
[c] Errors are 2σ based on counting statistics.

TABLE 1-B

RADIONUCLIDE CONCENTRATIONS IN BASELINE WATER SAMPLES

Location[a]	Radionuclide Concentrations (pCi/l)	
	Gross Alpha	Gross Beta
W1	0.95 ± 0.93 [b]	4.79 ± 1.15
W2	0.95 ± 0.94	9.17 ± 1.31
W3	0.55 ± 0.78	2.73 ± 1.05
W4	0.63 ± 0.89	5.37 ± 1.17
W5	0.73 ± 0.68	<0.64
W6	1.87 ± 1.84	14.3 ± 2.4
W7	1.16 ± 0.66	<0.63
Range	0.55 to 1.87	<0.63 to 14.3

[a] Refer to Figure 6.
[b] Errors are 2σ based on counting statistics.

TABLE 2

DIRECT RADIATION LEVELS
MEASURED AT 20 M GRID INTERVALS

Grid	Location	Gamma Exposure Rates at 1 m Above the Surface (µR/h)	Gamma Exposure Rates at the Surface (µR/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (µrad/h)
900N	90W	7	8	14
900N	80W	8	8	10
900N	60W	7	8	28
900N	40W	7	7	7
900N	20W	8	8	20
900N	0E	9	9	18
900N	20E	7	8	12
900N	40E	7	7	9
900N	60E	7	8	8
900N	80E	7	8	8
900N	100E	7	7	17
900N	120E	7	7	7
900N	140E	7	7	13
900N	160E	7	8	13
900N	180E	7	7	7
900N	200E	6	7	13
900N	220E	7	7	10
880N	90W	8	8	a
880N	80W	8	8	a
880N	60W	8	8	a
880N	40W	8	8	a
880N	20W	8	8	a
880N	0E	9	9	11
880N	20E	8	8	a
880N	40E	8	8	a
880N	60E	8	8	a
880N	80E	8	8	a
880N	100E	8	8	a
880N	120E	8	8	a
880N	140E	8	8	a
880N	160E	8	8	a
880N	180E	8	8	a
880N	200E	8	8	a
880N	220E	8	8	a
860N	90W	9	10	27
860N	80W	9	10	21
860N	60W	9	10	23
860N	40W	10	12	19
860N	20W	9	9	13
860N	0E	9	9	12
860N	20E	7	8	12
860N	40E	7	7	19

TABLE 2, cont.

DIRECT RADIATION LEVELS
MEASURED AT 20 M GRID INTERVALS

Grid	Location	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μrad/h)
860N	60E	7	8	8
860N	80E	7	7	7
860N	100E	7	7	16
860N	120E	7	8	18
860N	140E	7	8	19
860N	160E	7	7	13
860N	180E	7	8	16
860N	200E	7	8	24
860N	220E	7	7	19
840N	90W	8	8	18
840N	80W	9	9	16
840N	60W	10	10	30
840N	40W	11	11	22
840N	20W	9	9	21
840N	0E	9	9	21
840N	20E	8	7	12
840N	40E	7	7	20
840N	60E	7	8	10
840N	80E	7	8	8
840N	100E	8	8	8
840N	120E	8	8	31
840N	140E	7	7	13
840N	160E	7	7	13
840N	180E	7	8	8
840N	200E	8	7	7
840N	220E	7	7	9
820N	90W	8	8	11
820N	80W	8	8	22
820N	60W	8	8	24
820N	40W	20	29	69
820N	20W	7	6	19
820N	0E	9	12	19
820N	20E	9	8	18
820N	40E	8	8	15
820N	60E	8	8	14
820N	80E	8	8	25
820N	100E	8	9	22
820N	120E	8	8	28
820N	140E	7	7	7
820N	160E	7	7	16
820N	180E	7	7	12
820N	200E	7	8	12

TABLE 2, cont.

DIRECT RADIATION LEVELS
MEASURED AT 20 M GRID INTERVALS

Grid	Location	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μrad/h)
820N	220E	7	7	10
800N	90W	8	8	28
800N	80W	9	9	23
800N	60W	8	8	19
800N	40W	7	7	10
800N	20W	6	5	14
800N	0E	9	11	28
800N	20E	8	8	11
800N	40E	7	9	8
800N	60E	9	8	19
800N	80E	7	7	14
800N	100E	7	8	13
800N	120E	8	8	17
800N	140E	7	8	8
800N	160E	7	7	15
800N	180E	7	7	9
800N	200E	7	7	10
800N	220E	7	7	13
780N	90W	8	8	15
780N	80W	7	7	23
780N	60W	7	8	12
780N	40W	8	12	25
780N	20W	6	6	6
780N	0E	9	10	18
780N	20E	7	7	7
780N	40E	8	7	13
780N	60E	7	7	11
780N	80E	7	7	7
780N	100E	7	7	9
780N	120E	7	8	11
780N	140E	7	7	7
780N	160E	7	8	9
780N	180E	7	8	15
780N	200E	7	8	12
780N	220E	7	8	11
760N	90W	8	8	18
760N	80W	7	8	22
760N	60W	7	7	7
760N	40W	7	7	9
760N	20W	7	8	9
760N	0E	9	10	28
760N	20E	8	8	21

TABLE 2, cont.

DIRECT RADIATION LEVELS
MEASURED AT 20 M GRID INTERVALS

Grid	Location	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μrad/h)
760N	40E	7	7	23
760N	60E	7	7	13
760N	80E	7	7	7
760N	100E	7	7	15
760N	120E	7	7	7
760N	140E	7	7	12
760N	160E	7	7	20
760N	180E	7	8	25
760N	200E	8	8	8
760N	220E	7	7	7
740N	90W	7	7	9
740N	80W	6	6	11
740N	60W	7	8	16
740N	40W	7	7	19
740N	20W	7	7	12
740N	0E	9	9	18
740N	20E	6	6	8
740N	40E	5	5	5
740N	60E	6	6	14
740N	80E	5	5	5
740N	100E	5	6	6
740N	120E	6	7	7
740N	140E	7	7	10
740N	160E	7	7	12
740N	180E	7	7	16
740N	200E	7	7	9
740N	220E	8	7	7
720N	90W	9	9	12
720N	80W	7	7	7
720N	60W	6	7	10
720N	40W	6	6	8
720N	20W	7	7	11
720N	0E	9	8	8
720N	20E	6	5	5
720N	40E	6	7	7
720N	60E	5	6	6
720N	80E	6	6	6
720N	100E	5	5	5
720N	120E	7	6	11
720N	140E	6	7	7
720N	160E	7	7	7
720N	180E	7	7	7

TABLE 2, cont.

DIRECT RADIATION LEVELS
MEASURED AT 20 M GRID INTERVALS

Grid	Location	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μrad/h)
720N	200E	7	7	11
720N	220E	7	7	7
700N	90W	8	9	9
700N	80W	6	6	6
700N	60W	6	5	5
700N	40W	a	a	a
700N	20W	7	7	7
700N	0E	9	9	15
700N	20E	5	5	5
700N	40E	6	5	5
700N	60E	5	5	5
700N	80E	6	6	6
700N	100E	6	6	6
700N	120E	7	7	7
700N	140E	6	6	6
700N	160E	7	7	7
700N	180E	7	7	7
700N	200E	7	7	7
700N	220E	7	7	7
680N	90W	8	8	18
680N	80W	7	7	7
680N	60W	a	a	a
680N	40W	a	a	a
680N	20W	7	7	7
680N	0E	8	9	21
680N	20E	5	5	11
680N	40E	5	6	14
680N	60E	6	5	5
680N	80E	6	6	6
680N	100E	6	6	6
680N	120E	6	8	15
680N	140E	6	5	5
680N	160E	8	12	26
680N	180E	7	7	13
680N	200E	6	7	24
680N	220E	7	7	11
660N	90W	8	7	23
660N	80W	6	7	20
660N	60W	a	a	a
660N	40W	a	a	a
660N	20W	5	6	10
660N	0E	7	8	24

TABLE 2, cont.

DIRECT RADIATION LEVELS
MEASURED AT 20 M GRID INTERVALS

Grid	Location	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μrad/h)
660N	20E	5	5	5
660N	40E	5	5	5
660N	60E	5	5	9
660N	80E	5	6	6
660N	100E	5	5	11
660N	120E	6	7	17
660N	140E	6	7	7
660N	160E	7	7	37
660N	180E	7	7	15
660N	200E	7	7	10
660N	220E	6	7	14
640N	90W	8	8	9
640N	80W	6	6	6
640N	60W	5	5	8
640N	40W	6	6	6
640N	20W	4	5	5
640N	0E	8	8	8
640N	20E	6	7	30
640N	40E	7	7	9
640N	60E	7	7	7
640N	80E	7	7	10
640N	100E	6	7	21
640N	120E	7	8	28
640N	140E	7	7	14
640N	160E	7	7	12
640N	180E	7	8	31
640N	200E	7	7	7
640N	220E	7	7	7
620N	90W	7	7	7
620N	80W	7	7	19
620N	60W	7	8	23
620N	40W	5	5	12
620N	20W	6	5	9
620N	0E	14	18	35
620N	20E	6	6	10
620N	40E	6	7	10
620N	60E	5	5	5
620N	80E	6	6	6
620N	100E	8	9	19
620N	120E	7	7	20
620N	140E	8	7	12
620N	160E	7	7	7
620N	180E	7	8	18

TABLE 2, cont.

DIRECT RADIATION LEVELS
MEASURED AT 20 M GRID INTERVALS

Grid Location		Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μrad/h)
620N	200E	7	8	15
620N	220E	7	8	24
600N	90Q	8	8	8
600N	80W	7	7	23
600N	60W	6	6	15
600N	40W	a	a	a
600N	20W	7	7	12
600N	0E	9	9	9
600N	20E	a	a	a
600N	40E	a	a	a
600N	60E	7	7	16
600N	80E	5	5	11
600N	100E	7	6	6
600N	120E	7	7	7
600N	140E	8	9	20
600N	160E	8	10	23
600N	180E	7	8	12
600N	200E	14	14	31
600N	220E	12	12	25
580N	90W	9	8	9
580N	80W	8	8	18
580N	60W	7	7	10
580N	40W	a	a	a
580N	20W	7	7	27
580N	0E	9	9	9
580N	20E	10	12	15
580N	40E	9	9	25
580N	60E	13	13	13
580N	80E	9	12	18
580N	100E	8	7	7
580N	120E	7	7	16
580N	140E	a	a	a
580N	160E	a	a	a
580N	180E	6	6	15
580N	200E	7	7	13
580N	220E	7	7	15
560N	90W	8	8	24
560N	80W	8	8	17
560N	60W	7	7	7
560N	40W	7	7	20
560N	20W	6	6	6
560N	0E	9	9	22

TABLE 2, cont.

DIRECT RADIATION LEVELS
MEASURED AT 20 M GRID INTERVALS

Grid Location		Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μrad/h)
560N	20E	12	13	13
560N	40E	8	12	12
560N	60E	9	8	18
560N	80E	9	8	8
560N	100E	6	6	18
560N	120E	6	7	16
560N	140E	a	a	a
560N	160E	a	a	a
560N	180E	6	5	8
560N	200E	7	7	7
560N	220E	7	7	7
540N	90W	11	11	20
540N	80W	8	9	12
540N	60W	7	8	8
540N	40W	6	6	9
540N	20W	5	5	5
540N	0E	9	8	17
540N	20E	7	9	16
540N	40E	9	9	29
540N	60E	9	a	a
540N	80E	8	9	9
540N	100E	6	6	6
540N	120E	9	8	11
540N	140E	a	a	a
540N	160E	a	a	a
540N	180E	11	8	8
540N	200E	10	12	19

[a] Measurement not taken due to presence of building surface water, or other obstruction.

TABLE 3

DIRECT RADIATION LEVELS AT LOCATIONS
IDENTIFIED BY THE WALKOVER SURFACE SCAN

Grid Location[a]		Exposure Rate (μR/h)		Surface Dose Rate (μrad/h)	Sample Identification[b]	Contact Exposure Rate After Sample Removal (μR/h)
		Contact	1 m Above Surface			
862-870N	21-31W	20-39	----[c]	----	----	----
864N	27W	39	23	57	B1	43
862N	16W	20	----	----	----	----
852-856N	90-91W	17-20	----	----	----	----
840-846N	14-20W	22-48	----	----	----	----
844N	17W	48	26	109	B2	36
834-840N	32-40W	12-20	----	----	----	----
827N	60W	29	----	----	----	----
824N	26W	29	----	----	----	----
821N	48W	38	----	----	----	----
821N	43W	27	----	----	----	----
820N	56W	29	----	----	----	----
816N	18E	23	----	----	----	----
816N	21E	28	----	----	----	----
816N	24E	30	----	----	----	----
815N	23E	38	21	69	B3	29
809-820N	40-47W	17-29	----	----	----	----
812-820N	29-40W	29	----	----	----	----
800N	58W	27	----	----	----	----
687-691N	32-35E	17-36	----	----	----	----
689N	33E	36	----	----	----	----
616-625N	0-7E	14-31	----	----	----	----
621N	1E	21	----	----	----	----
600-603N	134-140E	17-29	----	----	----	----
602N	136E	29	14	40	B4	48
600-602N	160-176E	14-21	----	----	----	----

TABLE 3, cont.

DIRECT RADIATION LEVELS AT LOCATIONS
IDENTIFIED BY THE WALKOVER SURFACE SCAN

Grid Location		Exposure Rate (μR/h)		Surface Dose Rate (μrad/h)	Sample Identification	Contact Exposure Rate After Sample Removal (μR/h)
		Contact	1 m Above Surface			
600N	160E	21	13	21	B5	37
600N	170E	21	----	----	----	----
600-604N	206-220E	17-40	----	----	----	----
600N	215E	40	----	----	----	----
580-600N	212-214E	14-29	----	----	----	----
595N	213E	29	----	----	----	----
597N	196E	37	----	----	----	----
595-600N	48-52W	14-31	----	----	----	----
600N	51W	31	14	43	B6	58
595N	51W	31	-----	----	----	----
591-594N	48W	27	----	----	----	----
580-592N	49-51W	14-29	----	----	----	----
590N	49W	29	----	----	----	----
590N	196E	32	----	----	----	----
584-588N	47-48W	29	----	----	----	----
580-582N	60-63E	14-22	----	----	----	----
581N	62E	20	14	20	B7	25
575N	64E	20	----	----	----	----
569-572N	49-52E	14-20	----	----	----	----
564N	24E	23	----	----	----	----
561N	22E	20	----	----	----	----
559N	19E	31	17	43	B8	31
559N	21E	23	----	----	----	----
550-558N	50-56E	14-20	----	----	----	----
540-545N	1-11E	14-20	----	----	----	----

TABLE 3, cont.

DIRECT RADIATION LEVELS AT LOCATIONS
IDENTIFIED BY THE WALKOVER SURFACE SCAN

Grid Location	Exposure Rate (µR/h)		Surface Dose Rate (µrad/h)	Sample Identification	Contact Exposure Rate After Sample Removal (µR/h)
	Contact	1 m Above Surface			
544N 57E	27	----	----	----	----
543N 57E	33	----	----	----	----
541N 123E	240	21	450	B9	280
541N 179E	220	25	220	B10	1100

[a] Refer to Figure 7.
[b] Radionuclide analyses of samples presented in Table 5.
[c] Dash indicates measurement or sampling not performed.

TABLE 4

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES FROM 20 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
		Ra-226	U-235	U-238	Cs-137	Th-232
900N	90W	1.08 ± 0.29[a]	<0.33	1.92 ± 1.47	0.67 ± 0.15	0.67 ± 0.53
900N	80W	1.20 ± 0.41	<0.32	<1.01	0.65 ± 0.13	1.36 ± 0.45
900N	60W	0.58 ± 0.19	<0.12	0.78 ± 0.60	0.46 ± 0.12	0.51 ± 0.25
900N	40W	1.04 ± 0.36	<0.33	2.07 ± 1.15	0.61 ± 0.15	0.86 ± 0.32
900N	20W	0.85 ± 0.24	<0.15	0.80 ± 0.88	0.57 ± 0.11	0.84 ± 0.35
900N	9W	0.85 ± 0.24	<0.13	1.18 ± 0.64	0.94 ± 0.13	0.51 ± 0.29
900N	20E	1.03 ± 0.23	<0.32	<0.98	0.72 ± 0.19	1.84 ± 0.48
900N	40E	1.01 ± 0.21	<0.18	0.71 ± 0.87	0.40 ± 0.09	1.35 ± 0.35
900N	60E	0.90 ± 0.24	<0.26	<0.84	0.62 ± 0.11	0.61 ± 0.51
900N	80E	0.98 ± 0.28	<0.31	<0.93	0.68 ± 0.12	0.77 ± 0.34
900N	100E	0.98 ± 0.23	<0.17	0.90 ± 0.61	0.46 ± 0.10	1.10 ± 0.33
900N	120E	0.98 ± 0.24	<0.34	2.08 ± 1.12	0.74 ± 0.14	0.98 ± 0.49
900N	140E	0.83 ± 0.34	<0.18	1.29 ± 0.93	0.80 ± 0.15	0.89 ± 0.45
900N	160E	0.80 ± 0.20	<0.32	2.12 ± 1.55	0.57 ± 0.11	1.10 ± 0.46
900N	180E	0.73 ± 0.25	<0.15	0.51 ± 1.26	0.52 ± 0.12	0.58 ± 0.33
900N	200E	0.70 ± 0.20	<0.14	1.45 ± 0.43	0.38 ± 0.09	0.62 ± 0.28
900N	220E	0.96 ± 0.29	<0.27	<0.86	0.27 ± 0.08	0.84 ± 0.34
880N	90W	0.95 ± 0.30	<0.18	0.75 ± 0.59	0.98 ± 0.15	0.87 ± 0.44
880N	80W	1.20 ± 0.33	0.89 ± 0.70	3.64 ± 2.21	1.43 ± 0.18	1.26 ± 0.36
880N	60W	0.88 ± 0.25	<0.13	0.65 ± 0.96	1.01 ± 0.16	0.89 ± 0.37
880N	40W	1.45 ± 0.33	<0.39	<1.22	1.95 ± 0.22	1.12 ± 0.40
880N	20W	1.58 ± 0.38	<0.24	0.90 ± 0.80	2.57 ± 0.29	0.92 ± 0.56
880N	4W	0.93 ± 0.21	<0.29	<0.83	0.63 ± 0.12	0.65 ± 0.40
882N	10E	1.09 ± 0.28	<0.29	<0.98	0.60 ± 0.12	1.16 ± 0.29
880N	20E	0.83 ± 0.25	<0.15	1.62 ± 0.62	0.68 ± 0.11	0.60 ± 0.25
880N	40E	1.13 ± 0.28	<0.29	2.16 ± 1.92	0.40 ± 0.12	0.78 ± 0.44
880N	60E	1.08 ± 0.41	<0.21	0.66 ± 1.13	0.92 ± 0.18	0.68 ± 0.43

TABLE 4, cont.

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES FROM 20 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
		Ra-226	U-235	U-238	Cs-137	Th-232
880N	80E	0.48 ± 0.28	<0.17	1.04 ± 0.81	0.74 ± 0.14	0.70 ± 0.34
880N	100E	1.10 ± 0.29	<0.28	1.42 ± 1.77	0.77 ± 0.13	1.19 ± 0.39
880N	120E	1.09 ± 0.24	<0.17	0.71 ± 0.51	0.61 ± 0.13	0.78 ± 0.41
880N	140E	1.31 ± 0.26	<0.30	1.59 ± 1.01	0.48 ± 0.13	1.21 ± 0.37
880N	160E	0.68 ± 0.23	<0.16	1.17 ± 0.53	0.64 ± 0.12	0.66 ± 0.33
880N	180E	0.94 ± 0.23	<0.32	1.76 ± 1.93	0.83 ± 0.17	0.63 ± 0.29
880N	200E	0.91 ± 0.21	<0.17	1.38 ± 0.92	1.16 ± 0.16	1.13 ± 0.46
860N	90W	0.39 ± 0.49	<0.46	2.23 ± 2.05	0.63 ± 0.16	0.92 ± 0.58
860N	80W	1.84 ± 0.31	<0.20	1.74 ± 0.72	0.48 ± 0.13	0.90 ± 0.55
860N	60W	1.19 ± 0.25	<0.15	0.72 ± 0.51	0.43 ± 0.12	0.50 ± 0.29
860N	40W	1.58 ± 0.38	<0.38	<1.27	0.96 ± 0.20	1.41 ± 0.67
860N	20W	1.83 ± 0.30	<0.35	3.79 ± 1.16	0.24 ± 0.08	1.10 ± 0.32
860N	3W	1.15 ± 0.24	<0.16	1.54 ± 0.53	0.96 ± 0.15	0.54 ± 0.39
860N	20E	0.84 ± 0.23	<0.15	0.47 ± 0.42	0.08 ± 0.08	1.12 ± 0.37
860N	40E	0.79 ± 0.24	0.66 ± 0.50	2.25 ± 1.15	0.19 ± 0.06	1.45 ± 0.39
860N	60E	0.94 ± 0.26	<0.27	<0.87	0.65 ± 0.11	1.35 ± 0.38
860N	80E	1.00 ± 0.24	<0.17	2.17 ± 0.62	<0.05	1.10 ± 0.42
860N	100E	0.83 ± 0.26	<0.14	0.96 ± 0.72	<0.04	0.66 ± 0.44
860N	120E	0.70 ± 0.16	0.12 ± 0.40	1.22 ± 0.45	0.13 ± 0.07	0.66 ± 0.30
860N	140E	0.85 ± 0.29	0.32 ± 0.55	1.59 ± 1.78	0.63 ± 0.13	1.35 ± 0.38
860N	160E	0.80 ± 0.24	<0.16	0.55 ± 1.24	0.17 ± 0.09	1.10 ± 0.33
860N	180E	0.78 ± 0.24	<0.15	<0.41	0.14 ± 0.08	0.50 ± 0.24
860N	200E	0.80 ± 0.23	<0.26	0.28 ± 1.32	0.07 ± 0.06	1.45 ± 0.38
860N	220E	0.73 ± 0.21	<0.12	0.24 ± 0.44	<0.03	0.55 ± 0.36
840N	90W	1.00 ± 0.26	<0.16	0.19 ± 0.89	0.15 ± 0.09	1.04 ± 0.45
840N	80W	0.99 ± 0.21	<0.16	1.51 ± 0.66	0.60 ± 0.12	0.95 ± 0.59
840N	60W	1.13 ± 0.33	<0.28	<0.97	0.82 ± 0.14	0.94 ± 0.34

TABLE 4, cont.

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES FROM 20 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
		Ra-226	U-235	U-238	Cs-137	Th-232
840N	40W	1.78 ± 0.34	<0.36	<1.10	0.56 ± 0.17	1.06 ± 0.45
840N	20W	1.36 ± 0.26	<0.16	0.84 ± 0.79	<0.04	0.37 ± 0.16
840N	3W	0.79 ± 0.30	<0.14	0.54 ± 0.76	0.83 ± 0.11	0.42 ± 0.32
840N	20E	1.14 ± 0.29	<0.30	<0.92	0.26 ± 0.09	1.60 ± 0.44
840N	40E	1.04 ± 0.30	<0.34	2.85 ± 2.30	0.23 ± 0.12	1.19 ± 0.49
840N	60E	1.06 ± 0.20	<0.28	1.42 ± 1.29	<0.05	1.10 ± 0.35
840N	80E	0.78 ± 0.19	0.22 ± 0.32	1.06 ± 0.46	<0.04	0.75 ± 0.29
840N	100E	0.86 ± 0.23	<0.16	1.43 ± 0.59	0.35 ± 0.11	0.64 ± 0.24
840N	120E	0.91 ± 0.21	<0.26	1.00 ± 1.16	0.10 ± 0.06	0.84 ± 0.30
840N	140E	0.91 ± 0.21	<0.17	1.08 ± 0.52	0.31 ± 0.11	1.18 ± 0.36
840N	160E	0.74 ± 0.21	<0.15	0.95 ± 0.47	1.18 ± 0.06	0.53 ± 0.33
840N	180E	0.84 ± 0.31	<0.30	<0.91	0.68 ± 0.12	0.96 ± 0.29
840N	200E	0.84 ± 0.19	0.33 ± 0.31	0.71 ± 0.92	0.19 ± 0.07	0.93 ± 0.24
840N	220E	1.11 ± 0.25	<0.16	1.18 ± 0.49	0.47 ± 0.10	0.98 ± 0.56
820N	90W	0.96 ± 0.23	<0.28	1.76 ± 1.06	0.16 ± 0.06	1.13 ± 0.36
820N	80W	0.79 ± 0.18	<0.13	0.71 ± 0.12	0.31 ± 0.09	0.69 ± 0.37
820N	60W	0.85 ± 0.24	<0.29	1.07 ± 0.87	<0.04	1.25 ± 0.34
820N	40W	3.54 ± 0.34	<0.18	1.93 ± 0.64	0.36 ± 0.07	0.53 ± 0.26
820N	18W	1.04 ± 0.29	<0.36	2.12 ± 3.48	0.93 ± 0.17	1.65 ± 0.79
822N	3W	0.83 ± 0.19	<0.26	<0.78	0.44 ± 0.10	0.73 ± 0.24
820N	20E	0.95 ± 0.16	<0.15	1.06 ± 0.57	0.73 ± 0.12	0.67 ± 0.31
820N	40E	0.75 ± 0.31	<0.15	1.54 ± 0.81	0.40 ± 0.13	0.67 ± 0.43
820N	60E	0.65 ± 0.24	<0.15	0.91 ± 0.54	0.83 ± 0.07	0.72 ± 0.37
820N	80E	0.94 ± 0.26	<0.14	0.56 ± 1.07	0.12 ± 0.05	0.85 ± 0.24
820N	100E	1.18 ± 0.31	<0.36	1.96 ± 1.17	0.54 ± 0.17	1.06 ± 0.52
820N	120E	0.85 ± 0.24	<0.26	<0.85	0.47 ± 0.13	0.99 ± 0.38
820N	140E	0.81 ± 0.25	<0.14	1.46 ± 0.61	0.21 ± 0.10	0.79 ± 0.39

TABLE 4, cont.

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM 20 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
		Ra-226	U-235	U-238	Cs-137	Th-232
820N	160E	1.19 ± 0.24	<0.28	0.97 ± 2.25	0.17 ± 0.07	0.67 ± 0.25
820N	180E	b	b	b	b	b
820N	200E	1.10 ± 0.26	<0.29	4.45 ± 1.98	0.34 ± 0.11	1.09 ± 0.64
820N	220E	0.68 ± 0.36	<0.18	0.92 ± 1.08	0.18 ± 0.08	0.92 ± 0.58
780N	90W	0.85 ± 0.23	<0.27	2.83 ± 1.71	0.36 ± 0.10	1.05 ± 0.40
780N	80W	1.08 ± 0.26	<0.33	<0.92	0.39 ± 0.09	0.78 ± 0.41
780N	60W	0.65 ± 0.20	<0.13	0.59 ± 0.66	0.25 ± 0.08	0.74 ± 0.27
780N	40W	1.01 ± 0.28	<0.17	1.33 ± 0.54	0.60 ± 0.11	0.44 ± 0.32
780N	20W	0.54 ± 0.15	<0.23	<0.68	0.73 ± 0.11	0.40 ± 0.20
780N	3W	0.93 ± 0.20	<0.15	0.82 ± 0.91	0.73 ± 0.13	0.33 ± 0.30
780N	20E	0.86 ± 0.26	<0.32	2.25 ± 1.77	0.65 ± 0.13	0.88 ± 0.35
780N	40E	1.46 ± 0.33	<0.20	2.52 ± 0.70	0.41 ± 0.11	1.03 ± 0.50
780N	60E	0.86 ± 0.26	<0.15	1.34 ± 0.79	0.09 ± 0.05	0.79 ± 0.41
780N	80E	1.04 ± 0.25	<0.27	2.76 ± 1.25	0.19 ± 0.08	0.83 ± 0.37
780N	100E	1.23 ± 0.25	0.53 ± 0.46	1.40 ± 1.72	0.23 ± 0.13	1.04 ± 0.45
780N	120E	1.03 ± 0.23	<0.33	3.49 ± 1.87	0.59 ± 0.12	1.13 ± 0.39
780N	140E	0.78 ± 0.25	0.24 ± 0.55	0.68 ± 0.57	0.43 ± 0.12	1.05 ± 0.37
780N	160E	0.76 ± 0.21	<0.14	1.21 ± 1.19	0.58 ± 0.12	0.82 ± 0.41
780N	180E	0.71 ± 0.19	<0.16	1.14 ± 1.04	0.28 ± 0.08	1.21 ± 0.42
780N	200E	0.99 ± 0.35	<0.32	1.09 ± 1.90	0.46 ± 0.11	1.11 ± 0.40
780N	220E	1.08 ± 0.39	<0.37	3.02 ± 2.72	0.92 ± 0.19	1.32 ± 0.43
760N	90W	0.88 ± 0.24	<0.29	0.96 ± 1.82	0.21 ± 0.09	0.98 ± 0.34
760N	80W	1.00 ± 0.28	<0.27	<0.80	0.24 ± 0.08	0.96 ± 0.29
760N	60W	0.79 ± 0.21	<0.14	0.41 ± 0.44	0.05 ± 0.07	0.74 ± 0.26
760N	40W	0.88 ± 0.29	<0.28	1.22 ± 1.69	<0.04	0.83 ± 0.31
760N	20W	0.89 ± 0.26	<0.18	1.65 ± 0.60	0.58 ± 0.13	0.81 ± 0.27

TABLE 4, cont.

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES FROM 20 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
		Ra-226	U-235	U-238	Cs-137	Th-232
760N	4W	0.94 ± 0.25	<0.31	3.82 ± 1.81	0.74 ± 0.17	0.49 ± 0.41
760N	20E	1.11 ± 0.26	<0.30	<0.93	0.76 ± 0.15	0.76 ± 0.37
760N	40E	1.03 ± 0.35	<0.18	2.82 ± 1.16	0.15 ± 0.12	1.31 ± 0.44
760N	60E	0.90 ± 0.28	<0.15	0.81 ± 0.72	0.15 ± 0.10	0.89 ± 0.32
760N	80E	1.11 ± 0.33	<0.28	1.59 ± 1.71	<0.05	1.16 ± 0.35
760N	100E	0.73 ± 0.31	0.30 ± 0.18	1.05 ± 1.15	0.17 ± 0.06	0.85 ± 0.42
760N	120E	0.99 ± 0.24	<0.30	1.74 ± 1.89	0.25 ± 0.14	0.91 ± 0.42
760N	140E	0.74 ± 0.23	<0.29	2.06 ± 2.00	0.49 ± 0.11	0.74 ± 0.35
760N	160E	0.73 ± 0.29	<0.17	<0.44	0.42 ± 0.11	0.49 ± 0.24
760N	180E	0.89 ± 0.20	<0.27	6.54 ± 1.53	0.60 ± 0.12	0.85 ± 0.45
760N	200E	0.94 ± 0.19	<0.30	<0.86	<0.04	0.83 ± 0.35
760N	220E	0.59 ± 0.20	0.27 ± 0.25	0.76 ± 0.73	0.19 ± 0.07	0.78 ± 0.27
740N	90W	1.18 ± 0.26	<0.34	1.40 ± 1.46	0.21 ± 0.10	1.02 ± 0.45
740N	80W	1.13 ± 0.26	<0.14	0.94 ± 0.68	0.21 ± 0.07	0.34 ± 0.25
740N	60W	0.88 ± 0.23	<0.14	0.78 ± 1.32	0.18 ± 0.10	0.63 ± 0.26
740N	40W	0.83 ± 0.30	<0.31	1.97 ± 2.04	0.55 ± 0.14	1.04 ± 0.32
740N	20W	1.08 ± 0.29	<0.17	1.46 ± 0.62	0.25 ± 0.10	1.05 ± 0.34
740N	3W	1.96 ± 0.43	<0.20	1.71 ± 0.68	0.98 ± 0.16	0.62 ± 0.30
740N	20E	0.68 ± 0.20	<0.25	<0.72	0.60 ± 0.11	0.44 ± 0.24
740N	40E	0.74 ± 0.16	<0.23	<0.70	0.70 ± 0.11	0.85 ± 0.40
740N	60E	1.09 ± 0.26	<0.40	<1.09	0.55 ± 0.16	1.09 ± 0.42
740N	80E	b	b	b	b	b
740N	100E	0.56 ± 0.17	<0.13	0.91 ± 0.80	0.86 ± 0.11	0.26 ± 0.21
740N	120E	0.80 ± 0.25	<0.27	1.92 ± 1.14	0.48 ± 0.11	0.80 ± 0.54
740N	140E	0.74 ± 0.21	<0.15	0.64 ± 0.51	0.46 ± 0.11	1.05 ± 0.40
740N	160E	0.90 ± 0.23	<0.33	2.69 ± 2.36	0.33 ± 0.12	0.81 ± 0.41

TABLE 4, cont.

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM 20 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
		Ra-226	U-235	U-238	Cs-137	Th-232
740N	180E	0.65 ± 0.25	<0.16	2.10 ± 0.64	0.47 ± 0.13	0.83 ± 0.69
740N	200E	0.85 ± 0.30	<0.15	0.64 ± 0.84	0.23 ± 0.10	0.97 ± 0.30
740N	220E	0.74 ± 0.31	<0.34	<1.10	0.54 ± 0.17	1.24 ± 0.36
720N	90W	0.59 ± 0.58	<0.26	0.82 ± 0.75	0.73 ± 0.13	0.78 ± 0.45
720N	80W	0.94 ± 0.38	<0.27	1.89 ± 1.23	0.10 ± 0.09	<0.12
720N	60W	0.80 ± 0.25	<0.32	<0.88	0.16 ± 0.06	1.09 ± 0.52
720N	40W	0.93 ± 0.24	<0.28	<0.85	0.20 ± 0.09	0.79 ± 0.38
720N	20W	0.89 ± 0.25	<0.17	1.53 ± 0.58	0.64 ± 0.15	0.94 ± 0.40
720N	3W	1.41 ± 0.34	<0.20	2.50 ± 0.75	0.59 ± 0.12	1.21 ± 0.35
720N	20E	0.88 ± 0.19	<0.23	1.40 ± 1.21	0.39 ± 0.08	0.65 ± 0.23
720N	40E	0.70 ± 0.18	<0.13	1.17 ± 0.43	0.42 ± 0.10	0.41 ± 0.27
720N	60E	0.90 ± 0.30	<0.23	1.07 ± 1.44	0.35 ± 0.07	0.80 ± 0.29
720N	80E	0.46 ± 0.15	<0.22	<0.62	0.64 ± 0.10	0.59 ± 0.23
720N	100E	0.34 ± 0.14	<0.12	0.70 ± 0.37	0.78 ± 0.10	0.16 ± 0.24
720N	120E	0.81 ± 0.21	<0.35	0.90 ± 3.93	0.37 ± 0.20	1.24 ± 0.40
720N	140E	0.94 ± 0.21	<0.17	1.43 ± 0.50	0.13 ± 0.08	0.97 ± 0.37
720N	160E	1.14 ± 0.34	<0.41	<1.14	0.54 ± 0.15	1.19 ± 0.39
720N	180E	0.89 ± 0.18	<0.14	1.02 ± 0.89	0.26 ± 0.08	0.87 ± 0.25
720N	200E	0.80 ± 0.17	<0.12	0.23 ± 0.28	0.07 ± 0.05	0.63 ± 0.30
720N	220E	0.74 ± 0.25	<0.32	<1.00	0.24 ± 0.15	<0.31
700N	87W	2.59 ± 0.45	<0.30	3.36 ± 1.94	0.66 ± 0.14	1.06 ± 0.53
700N	80W	1.00 ± 0.36	<0.27	2.48 ± 2.19	0.35 ± 0.18	0.51 ± 0.40
700N	60W	b	b	b	b	b
700N	40W	b	b	b	b	b
700N	20W	0.63 ± 0.28	0.35 ± 0.76	<1.14	0.50 ± 0.16	1.58 ± 0.46
700N	3W	1.01 ± 0.33	<0.26	<0.90	0.69 ± 0.14	0.86 ± 0.41
700N	20E	0.49 ± 0.18	<0.11	0.52 ± 0.57	0.95 ± 0.11	0.29 ± 0.24

TABLE 4, cont.

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM 20 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
		Ra-226	U-235	U-238	Cs-137	Th-232
700N	40E	1.34 ± 0.24	<0.28	1.15 ± 1.66	0.37 ± 0.09	0.65 ± 0.27
700N	60E	0.40 ± 0.20	<0.14	0.88 ± 0.52	0.35 ± 0.09	0.38 ± 0.31
700N	80E	0.53 ± 0.20	<0.23	<0.66	0.53 ± 0.11	0.39 ± 0.18
700N	100E	0.80 ± 0.21	<0.12	0.61 ± 0.37	0.08 ± 0.08	0.69 ± 0.41
700N	120E	1.03 ± 0.26	<0.16	1.24 ± 1.09	0.30 ± 0.15	1.15 ± 0.36
700N	140E	1.00 ± 0.25	<0.29	3.28 ± 1.93	0.89 ± 0.15	1.04 ± 0.31
700N	160E	1.46 ± 0.34	<0.36	1.77 ± 1.13	0.39 ± 0.19	1.92 ± 0.63
700N	180E	0.94 ± 0.24	<0.18	0.95 ± 0.73	0.25 ± 0.13	1.08 ± 0.49
700N	200E	0.89 ± 0.24	<0.16	0.66 ± 0.46	0.37 ± 0.10	0.63 ± 0.32
700N	220E	0.89 ± 0.21	0.49 ± 0.73	4.43 ± 1.53	0.45 ± 0.13	0.94 ± 0.44
680N	87W	0.99 ± 0.40	<0.31	2.57 ± 1.16	0.68 ± 0.20	0.95 ± 0.52
680N	80W	1.19 ± 0.30	<0.24	<0.88	0.39 ± 0.14	0.60 ± 0.42
680N	60W	b	b	b	b	b
680N	40W	b	b	b	b	b
680N	20W	0.94 ± 0.30	<0.25	1.77 ± 1.10	0.65 ± 0.20	1.05 ± 0.70
680N	3W	1.13 ± 0.32	<0.34	2.75 ± 2.02	1.10 ± 0.16	1.14 ± 0.44
680N	3E	0.85 ± 0.22	<0.19	<0.73	1.64 ± 0.22	0.95 ± 0.38
680N	20E	0.71 ± 0.26	0.19 ± 0.40	<0.56	0.46 ± 0.10	0.35 ± 0.28
680N	40E	0.76 ± 0.22	<0.18	<0.65	0.40 ± 0.12	0.78 ± 0.32
680N	60E	0.43 ± 0.28	<0.15	<0.50	0.55 ± 0.10	0.32 ± 0.20
680N	80E	0.50 ± 0.20	<0.13	<0.64	0.11 ± 0.05	0.56 ± 0.24
680N	100E	0.45 ± 0.18	<0.15	0.31 ± 0.87	0.64 ± 0.10	0.44 ± 0.24
680N	120E	0.48 ± 0.52	<0.41	4.84 ± 1.92	0.63 ± 0.11	0.60 ± 0.76
680N	140E	1.10 ± 0.24	<0.29	1.73 ± 1.72	<0.09	0.95 ± 0.40
680N	160E	0.29 ± 0.21	<0.16	<0.63	1.10 ± 0.16	0.26 ± 0.34
680N	180E	0.74 ± 0.38	<0.19	2.15 ± 1.74	0.49 ± 0.13	1.10 ± 0.46
680N	200E	0.89 ± 0.30	<0.28	0.90 ± 1.67	<0.04	0.94 ± 0.40

TABLE 4, cont.

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM 20 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
		Ra-226	U-235	U-238	Cs-137	Th-232
680N	220E	0.96 ± 0.27	<0.31	4.02 ± 1.65	0.41 ± 0.12	1.05 ± 0.66
660N	87W	1.18 ± 0.34	<0.31	1.60 ± 1.70	0.26 ± 0.10	0.92 ± 0.30
660N	80W	0.61 ± 0.21	<0.20	0.92 ± 1.31	0.86 ± 0.14	0.57 ± 0.24
660N	60W	b	b	b	b	b
660N	40W	b	b	b	b	b
660N	20W	b	b	b	b	b
660N	4E	1.24 ± 0.22	<0.24	<0.74	0.34 ± 0.09	0.92 ± 0.42
660N	20E	0.40 ± 0.16	<0.09	<0.52	0.75 ± 0.11	0.28 ± 0.18
660N	40E	0.39 ± 0.13	<0.12	<0.42	0.04 ± 0.03	0.47 ± 0.34
660N	60E	0.49 ± 0.21	<0.20	0.77 ± 0.96	1.07 ± 0.12	0.81 ± 0.20
660N	80E	0.69 ± 0.19	<0.13	1.17 ± 1.32	0.46 ± 0.11	0.68 ± 0.42
660N	100E	2.11 ± 0.45	<0.29	<0.87	1.34 ± 0.18	0.58 ± 0.29
660N	120E	0.84 ± 0.25	<0.26	<0.77	0.92 ± 0.17	1.19 ± 0.42
660N	140E	0.74 ± 0.26	<0.25	1.04 ± 1.30	0.30 ± 0.12	0.82 ± 0.34
660N	160E	1.31 ± 0.24	<0.28	2.58 ± 1.54	0.29 ± 0.14	0.74 ± 0.43
660N	180E	0.56 ± 0.22	<0.19	0.98 ± 1.22	0.12 ± 0.06	0.70 ± 0.31
660N	200E	0.76 ± 0.25	<0.18	1.28 ± 2.16	<0.04	0.71 ± 0.40
660N	220E	0.59 ± 0.22	<0.21	1.36 ± 1.41	<0.05	0.70 ± 0.37
640N	87W	0.64 ± 0.30	<0.22	<0.94	0.79 ± 0.14	0.65 ± 0.41
640N	80W	1.03 ± 0.29	<0.26	1.01 ± 0.75	0.24 ± 0.11	0.78 ± 0.29
640N	60W	b	b	b	b	b
640N	40W	b	b	b	b	b
640N	20W	b	b	b	b	b
640N	0	b	b	b	b	b
640N	20E	0.65 ± 0.29	<0.23	<0.67	0.66 ± 0.13	0.88 ± 0.32
640N	40E	1.03 ± 0.28	0.35 ± 0.73	4.34 ± 1.97	0.64 ± 0.12	1.17 ± 0.46
640N	60E	0.88 ± 0.33	<0.23	1.58 ± 2.89	0.56 ± 0.16	1.19 ± 0.43

TABLE 4, cont.

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM 20 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
		Ra-226	U-235	U-238	Cs-137	Th-232
640N	80E	0.86 ± 0.23	<0.23	1.11 ± 2.23	0.26 ± 0.09	1.29 ± 0.36
640N	100E	0.91 ± 0.23	<0.27	<0.86	0.45 ± 0.10	1.35 ± 0.38
640N	120E	0.86 ± 0.19	<0.29	3.72 ± 1.97	0.50 ± 0.10	0.97 ± 0.33
640N	140E	0.63 ± 0.26	<0.21	1.14 ± 1.60	0.65 ± 0.11	0.63 ± 0.27
640N	160E	1.09 ± 0.34	<0.26	4.35 ± 2.35	0.40 ± 0.13	1.09 ± 0.52
640N	180E	1.43 ± 0.29	<0.31	<1.05	0.67 ± 0.11	0.87 ± 0.33
640N	200E	3.29 ± 0.56	<0.28	1.00 ± 4.29	0.06 ± 0.10	0.92 ± 0.75
640N	220E	1.41 ± 0.39	<0.24	<0.77	0.43 ± 0.23	0.73 ± 0.84
620N	90W	0.81 ± 0.25	<0.23	<0.83	0.15 ± 0.09	1.09 ± 0.60
620N	80W	1.04 ± 0.26	<0.24	1.17 ± 2.11	0.70 ± 0.16	0.56 ± 0.28
620N	60W	0.65 ± 0.23	<0.22	<0.63	0.33 ± 0.12	0.66 ± 0.36
620N	40W	b	b	b	b	b
620N	20W	b	b	b	b	b
620N	0E	b	b	b	b	b
620N	20E	0.65 ± 0.23	<0.18	<0.69	0.61 ± 0.12	0.58 ± 0.36
620N	40E	1.33 ± 0.30	<0.25	1.23 ± 2.06	0.61 ± 0.16	0.89 ± 0.49
620N	60E	b	b	b	b	b
620N	80E	0.69 ± 0.30	<0.23	1.02 ± 1.72	0.45 ± 0.12	0.80 ± 0.42
620N	100E	0.70 ± 1.24	<0.27	1.74 ± 1.37	0.36 ± 0.10	1.24 ± 0.35
620N	120E	0.70 ± 0.26	<0.18	0.91 ± 1.86	0.25 ± 0.12	0.91 ± 0.41
620N	140E	0.69 ± 0.27	<0.21	0.65 ± 1.81	0.65 ± 0.14	0.95 ± 0.29
620N	160E	1.03 ± 0.40	0.76 ± 0.51	1.41 ± 1.82	1.24 ± 0.22	0.67 ± 0.46
620N	180E	1.51 ± 0.28	0.29 ± 0.70	<0.93	0.34 ± 0.14	0.75 ± 0.54
620N	200E	1.19 ± 0.40	0.23 ± 0.62	2.35 ± 1.48	0.53 ± 0.16	0.89 ± 0.44
620N	220E	0.83 ± 0.18	<0.25	<0.80	0.43 ± 0.11	0.86 ± 0.32
600N	90W	0.96 ± 0.26	<0.24	0.91 ± 2.02	0.61 ± 0.14	1.08 ± 0.41
600N	80W	0.66 ± 0.25	<0.27	<1.05	0.46 ± 0.12	0.90 ± 0.36
600N	60W	0.59 ± 0.23	<0.23	<0.99	0.35 ± 0.14	0.71 ± 0.32

TABLE 4, cont.

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES FROM 20 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
		Ra-226	U-235	U-238	Cs-137	Th-232
600N	50W	7.40 ± 0.65	0.85 ± 0.89	7.00 ± 1.83	0.23 ± 0.08	<0.26
600N	40W	b	b	b	b	b
600N	20W	0.44 ± 0.29	0.40 ± 0.52	1.51 ± 2.03	0.43 ± 0.14	1.00 ± 0.67
600N	3W	0.61 ± 0.23	0.52 ± 0.37	2.01 ± 1.22	0.41 ± 0.10	1.21 ± 0.33
600N	20E	b	b	b	b	b
600N	40E	b	b	b	b	b
596N	60E	0.75 ± 0.29	<0.23	1.94 ± 1.89	0.52 ± 0.14	0.78 ± 0.40
596N	80E	0.59 ± 0.20	<0.18	0.69 ± 2.20	0.29 ± 0.10	0.32 ± 0.10
600N	100E	0.91 ± 0.26	<0.20	1.20 ± 1.50	<0.04	0.68 ± 0.25
600N	120E	0.76 ± 0.26	<0.25	3.20 ± 1.45	0.53 ± 0.10	0.81 ± 0.41
600N	140E	1.01 ± 0.25	<0.19	2.05 ± 1.21	0.23 ± 0.11	0.78 ± 0.38
600N	160E	1.43 ± 0.31	<0.19	1.93 ± 1.93	0.33 ± 0.11	0.64 ± 0.57
600N	180E	1.14 ± 0.26	<0.25	2.80 ± 1.05	0.52 ± 0.09	0.81 ± 0.32
600N	200E	0.69 ± 0.23	<0.29	3.33 ± 1.36	<0.04	0.88 ± 0.38
600N	220E	2.94 ± 0.44	<0.27	2.50 ± 2.27	<0.05	0.76 ± 0.31
580N	90W	0.88 ± 0.19	<0.17	1.16 ± 1.35	0.36 ± 0.07	0.70 ± 0.34
580N	80W	0.76 ± 0.29	<0.22	1.68 ± 1.59	0.22 ± 0.12	0.68 ± 0.40
580N	60W	0.58 ± 0.26	<0.24	1.49 ± 1.80	0.39 ± 0.16	0.67 ± 0.31
580N	50W	0.91 ± 0.25	<0.27	2.12 ± 2.04	1.24 ± 0.23	0.65 ± 0.31
580N	40W	b	b	b	b	b
580N	20W	0.60 ± 0.20	<0.21	1.62 ± 2.05	0.37 ± 0.11	0.76 ± 0.30
580N	3W	0.65 ± 0.20	0.17 ± 0.63	1.84 ± 0.98	0.57 ± 0.13	0.77 ± 0.38
580N	20E	1.10 ± 0.34	<0.36	<1.10	0.69 ± 0.17	<0.30
580N	40E	2.00 ± 0.34	<0.36	3.54 ± 1.52	0.82 ± 0.15	0.44 ± 0.31
580N	60E	3.51 ± 0.45	0.82 ± 0.75	7.00 ± 1.76	0.67 ± 0.14	<0.29
580N	80E	0.95 ± 0.24	<0.23	<0.89	0.57 ± 0.14	0.61 ± 0.56
580N	100E	1.00 ± 0.23	<0.34	<1.15	0.58 ± 0.11	1.32 ± 0.51

TABLE 5

RADIONUCLIDE CONCENTRATIONS IN SURFACE SAMPLES
FROM LOCATIONS IDENTIFIED BY THE WALKOVER SCAN

Sample No.	Sample Type	Grid Location	Radionuclide Concentrations (pCi/g)[a] Ra-226	U-235[b]	U-238[b]	Cs-137	Th-232
B1	Rock	864N, 27W	36.1 ± 1.0[c]	2.81 ± 1.20	36.8 ± 2.3	<0.09	<0.36
B2	Rock	844N, 17W	49.5 ± 2.0	12.1 ± 3.5	53.4 ± 8.5	<0.18	<0.76
B3	Rock	815N, 23E	34.8 ± 1.5	2.28 ± 2.20	36.6 ± 9.8	<0.14	<0.61
B4	Rock	602N,136E	23.7 ± 1.3	<0.91	25.3 ± 7.8	0.19 ± 0.13	<0.43
B5	Rock	600N,160E	43.7 ± 1.1	4.82 ± 1.89	72.0 ± 26.2	0.13 ± 0.11	<0.53
B6	Rock	600N, 51W	25.3 ± 0.9	1.86 ± 1.08	30.7 ± 2.7	0.03 ± 0.05	0.75 ± 0.60
B7	Rock	581N, 62E	37.6 ± 1.7	3.72 ± 3.01	43.4 ± 7.4	<0.15	<0.69
B8	Rock	559N, 19E	26.7 ± 1.4	2.59 ± 2.33	19.0 ± 8.0	<0.13	<0.52
B9	Rock	541N,123E	990 ± 12	58.8 ± 16.2	94.8 ± 26.9	<1.01	84.5 ± 7.1
B10	Rock	541N,179E	4280 ± 30	170 ± 35	<58.3	<3.11	95.7 ± 22.8

[a] Refer to Table 3 for direct radiation levels.
[b] Large errors and poor detection sensitivities result from high activity of Ra-226.
[c] Errors are 2σ based on counting statistics.

TABLE 6

RADIONUCLIDE CONCENTRATIONS IN BOREHOLE SOIL SAMPLES

Borehole No.[a]	Grid Location	Depth (m)	Radionuclide Concentrations (pCi/g)				
			Ra-226	U-235	U-238	Cs-137	Th-232
H1	860N, 30W	Surface[b]	1.09 ± 0.26[c]	<0.30	0.85 ± 1.86	<0.03	1.42 ± 0.32
H2	860N, 30E	Surface[b]	0.88 ± 0.21	<0.17	0.90 ± 0.97	0.38 ± 0.12	0.71 ± 0.40
H3	840N,152E	Surface[b]	1.43 ± 0.31	<0.30	1.73 ± 1.65	<0.04	1.80 ± 0.45
H4	770N, 70E	Surface[b]	0.91 ± 0.24	0.13 ± 0.33	1.40 ± 0.77	0.07 ± 0.09	1.00 ± 0.33
H5	620N,195E	Surface[b]	0.80 ± 0.16	<0.26	1.63 ± 1.31	0.12 ± 0.08	0.92 ± 0.31
H6	570N, 20E	Surface[b]	0.93 ± 0.20	<0.14	0.58 ± 0.81	<0.02	0.77 ± 0.27
H7	580N, 83W	Surface[b]	0.93 ± 0.41	<0.32	<0.98	0.31 ± 0.11	2.06 ± 0.55
H8	614N, 85W	Surface[b]	0.89 ± 0.28	<0.17	0.77 ± 0.53	0.56 ± 0.10	0.54 ± 0.42
H9	620N, 70W	Surface[b]	1.28 ± 0.36	<0.36	1.72 ± 1.85	0.59 ± 0.16	0.90 ± 0.35
H10	600N, 51W	Surface	25.3 ± 0.9	1.86 ± 1.08	30.7 ± 2.7	0.03 ± 0.05	0.75 ± 0.60
		0.15	20.6 ± 0.9	2.60 ± 1.35	39.1 ± 3.5	<0.09	<0.38
		0.50	0.83 ± 0.24	<0.14	1.22 ± 0.47	<0.03	0.82 ± 0.31
H11	844N, 17W	Surface	49.5 ± 2.0	12.1 ± 3.5	53.4 ± 8.5	<0.18	<0.76
		0.15	0.98 ± 0.20	<0.15	1.55 ± 0.54	<0.02	0.97 ± 0.35
		0.90	1.16 ± 0.23	<0.29	1.35 ± 0.95	<0.04	1.06 ± 0.31

TABLE 6, cont.

RADIONUCLIDE CONCENTRATIONS IN BOREHOLE SOIL SAMPLES

Borehole No.	Grid Location	Depth (m)	Radionuclide Concentrations (pCi/g)				
			Ra-226	U-235	U-238	Cs-137	Th-232
H12	815N, 23E	Surface	34.8 ± 1.5	2.28 ± 2.20	36.6 ± 9.8	<0.14	<0.61
		0.15	1.16 ± 0.29	<0.15	1.11 ± 0.87	<0.02	0.98 ± 0.56
		0.90	2.16 ± 0.39	<0.33	2.79 ± 1.24	<0.04	1.15 ± 0.33
H13	541N,179E	Surface	4280 ± 30	170 ± 35	<58.3	<3.11	95.7 ± 22.8
		0.30	12.3 ± 0.8	<0.64	<1.68	<0.07	2.34 ± 0.64
		1.20	3.65 ± 0.41	<0.19	<0.47	<0.03	0.78 ± 0.31
H14	541N,123E	Surface	990 ± 12	58.8 ± 16.2	94.8 ± 26.9	<1.01	84.5 ± 7.1
		0.15	1.04 ± 0.30	<0.26	<0.79	<0.03	0.93 ± 0.38

[a] Refer to Figure 4.
[b] Subsurface sampling was not performed based on negative findings of the borehole gamma scans.
[c] Errors are 2σ based on counting statistics.

TABLE 7

RADIONUCLIDE CONCENTRATIONS IN WATER SAMPLES

Sample No.	Sample Type	Grid Location	Radionuclide Concentrations (pCi/l) Gross Alpha[c]	Gross Beta
W1	Surface[a]	570N, 79E	1.62 ± 0.47[d]	2.77 ± 0.47
W2	Surface[a]	560N, 45E	1.83 ± 0.51	10.3 ± 0.7
W3	Subsurface Borehole H1[b]	860N, 30W	7.01 ± 1.65	4.20 ± 1.19
W4	Subsurface Borehole H2[b]	860N, 30E	10.2 ± 2.1	6.98 ± 1.58
W5	Subsurface Borehole H4[b]	770N, 70E	8.85 ± 3.78	11.2 ± 4.3
W6	Subsurface Borehole H9[b]	620N, 70W	7.59 ± 3.79	4.74 ± 4.01
W7	Subsurface Borehole H5[b]	620N,195E	3.84 ± 1.06	5.03 ± 0.98
W8	Subsurface Borehole H8[b]	614N, 85W	10.6 ± 3.4	14.7 ± 3.3
W9	Subsurface Borehole H6[b]	570N, 20E	6.54 ± 1.63	7.89 ± 1.59
W10	Subsurface Borehole H13[b]	541N,179E	1.54 ± 0.80	2.65 ± 0.88
W11	Subsurface Borehole H14[b]	541N,123E	1.08 ± 0.66	1.15 ± 0.80

[a] Refer to Figure 5.
[b] Refer to Figure 4.
[c] Large amounts of dissolved solids resulted in relatively poor detection sensitivities and high errors for gross alpha analysis.
[d] Errors are 2σ based on counting statistics.

TABLE 8

SUMMARY OF RESULTS OF BUILDING SURVEYS

Building[a]	Gamma Exposure Rates 1 Meter Above the Floor (μR/h)	Directly Measured Surface Contamination Levels		
		Alpha (d/m/100 cm^2)	Beta-Gamma (d/m/100 cm^2)	Beta-Gamma Dose Rate (mrad/h)
A	4.4-6.7	<26-103	<394-634	.01-.03
B	4.2-5.5	<26-77	<394	.01-.02
C	4.9-5.7	<26-64	<394	.01
D	5.5-5.9	51-103	<394	.01-.02
E	5.9-6.4	<26-51	<394	.01

[a] Refer to Figure 2.

TABLE 9

SUMMARY OF AREAS ON PROPERTY V WHICH EXCEED RESIDUAL CONTAMINATION CRITERIA

Grid Location[a]		Principal Radionuclides[b]	Estimated Quantities of Material Exceeding Guidelines			Remarks
			Area (m^2)	Average Depth (m)	Volume (m^3)	
862-870N	21-31W	Ra-226, U-238[c]	80	0.15	12	General areas of crushed rock fill.
852-856N	90-91W	Ra-226, U-238[c]	4	0.15	0.6	
840-846N	14-20W	Ra-226, U-238[c]	36	0.15	5.4	
834-840N	32-40W	Ra-226, U-238[c]	48	0.15	7.2	
809-820N	40-47W	Ra-226, U-238[c]	77	0.15	11.6	
812-820N	29-40W	Ra-226, U-238[c]	88	0.15	13.2	
687-691N	32-35E	Ra-226, U-238[c]	12	0.15	1.8	
616-625N	0-7E	Ra-226, U-238[c]	63	0.15	9.5	
600-603N	134-140E	Ra-226, U-238[c]	18	0.15	2.7	
600-602N	160-176E	Ra-226, U-238[c]	32	0.15	4.8	
600-604N	206-220E	Ra-226, U-238[c]	56	0.15	8.4	
580-600N	212-214E	Ra-226, U-238[c]	40	0.15	6	
580-600N	47-52W	Ra-226, U-238[c]	100	0.15	15	
580-582N	60-63E	Ra-226, U-238[c]	6	0.15	0.9	
569-572N	49-52E	Ra-226, U-238[c]	9	0.15	1.4	
550-558N	50-56E	Ra-226, U-238[c]	48	0.15	7.2	
540-545N	1-11E	Ra-226, U-238[c]	50	0.15	7.5	
862N	16W	Ra-226, U-238[c]	--[d]	--	--	Isolated "hot spots" containing crushed rock or individual pieces of rock-like material. Unless indicated otherwise, average depth is approx. 0.15 m. The volume of material at each of these locations is estimated to be less than 1 m^3.
827N	60W	Ra-226, U-238[c]	--	--	--	
824N	26W	Ra-226, U-238[c]	--	--	--	
821N	48W	Ra-226, U-238[c]	--	--	--	
821N	43W	Ra-226, U-238[c]	--	--	--	
820N	56W	Ra-226, U-238[c]	--	--	--	
816N	18E	Ra-226, U-238[c]	--	--	--	
816N	21E	Ra-226, U-238[c]	--	--	--	
816N	24E	Ra-226, U-238[c]	--	--	--	
815N	23E	Ra-226, U-238[c]	--	--	--	
800N	58W	Ra-226, U-238[c]	--	--	--	
597N	196E	Ra-226, U-238[c]	--	--	--	
590N	196E	Ra-226, U-238[c]	--	--	--	
575N	64E	Ra-226, U-238[c]	--	--	--	
564N	24E	Ra-226, U-238[c]	--	--	--	
561N	22E	Ra-226, U-238[c]	--	--	--	
559N	19E	Ra-226, U-238[c]	--	--	--	
559N	21E	Ra-226, U-238[c]	--	--	--	
544N	57E	Ra-226, U-238[c]	--	--	--	
543N	57E	Ra-226, U-238[c]	--	--	--	
541N	123E	Ra-226 [e]	--	--	--	
541N	179E	Ra-226 [e]	--	0.30	--	

[a] Refer to Figure 7.

[b] Based on information from sample analysis, direct radiation levels, locations, distribution, and physical characteristics.

[c] Believed to be of natural origin and not attributable to previous MED/AEC operations.

[d] Dash indicates determination not made.

[e] Considered to have resulted from previous MED/AEC activities.

REFERENCES

1. E.A. Vierzba and A. Wallo, Background Report and Resurvey Recommendations for the Atomic Energy Commission Portion of the Lake Ontario Ordnance Works, Aerospace Corp., November 1982.

2. Oak Ridge Operations, U.S. Atomic Energy Commission, Radiation Survey and Decontamination Report of the Lake Ontario Ordnance Works Site, Oak Ridge, TN, January 1973.

3. T.E. Myrick, et al., Preliminary Results of the Ground-Level Gamma-Ray Scan Survey of the Former Lake Ontario Ordnance Works Site - Draft Report, ORNL, Oak Ridge, TN, 1981.

APPENDIX A

INSTRUMENTATION AND ANALYTICAL PROCEDURES

APPENDIX A

Instrumentation and Analytical Procedures

Gamma Scintillation Measurements

Walkover surface scans and measurements of gamma exposure rates were performed using Eberline Model PRM-6 portable ratemeters with Victoreen Model 489-55 gamma scintillation probes containing 3.2 cm x 3.8 cm NaI(Tl) scintillation crystals. Count rates were converted to exposure rates (μR/h) using factors determined by comparing the response of the scintillation detector with that of a Reuter Stokes model RSS-111 pressurized ionization chamber at locations on the Niagara Falls Storage Site and off-site properties.

Beta-Gamma Dose Rate Measurements

Measurements were performed using Eberline "Rascal," Model PRS-1, portable scaler/ratemeters with Model HP-260 thin-window, pancake G-M, beta probes. Dose rates (μrad/h) were determined by comparison of the response of a Victoreen Model 440 ionization chamber survey meter to that of the G-M probes.

Borehole Logging

Borehole gamma radiation measurements were performed using a Victoreen Model 489-55 gamma scintillation probe, connected to a Ludlum Model 2200 portable scaler. The scintillation probe was shielded by a 1.25 cm thick lead shield with four 2.5 cm x 7 mm holes evenly spaced around the region of the scintillation crystal. The probe was lowered into each hole using a tripod holder with a small winch. Measurements were performed at 15-30 cm intervals in all holes. The logging data was used to identify regions of possible residues and guide the selection of subsurface soil sampling locations. Due to the varying ratios of Ra-226, U-235, U-238, Th-232, and Cs-137, there was no attempt to estimate soil radionuclide concentrations directly from the logging results.

Soil Sample Analysis

Gamma Spectrometry

Soil samples were dried, mixed, and a portion placed in a 0.5 l Marinelli beaker. The quantity placed in each beaker was chosen to reproduce the calibrated counting geometry and ranged from 600 to 800 g of soil. Net soil weights were determined and the samples counted using intrinsic germanium and Ge(Li) detectors coupled to a Nuclear Data model ND-680 pulse height analyzer system. Background and Compton stripping, peak search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system. Energy peaks used for determination of radionuclides of concern were:

Ra-226 - 0.609 MeV from Bi-214 (corrected for equilibrium conditions)
U-235 - 0.143 MeV
U-238 - 0.094 MeV from Th-234 (secular equilibrium assumed)
Th-232 - 0.911 MeV from Ac-228 (secular equilibrium assumed)
Cs-137 - 0.662 MeV

Water Sample Analysis

Water samples were rough-filtered through Whatman No. 2 filter paper. Remaining suspended solids were removed by subsequent filtration through 0.45 μm membrane filters. The filtrate was acidified by addition of 10 ml of concentrated nitric acid. A known volume of each sample was evaporated to dryness and counted for gross alpha and gross beta using a Tennelec Model LB 5100 low-background proportional counter.

Calibration and Quality Assurance

With the exception of the exposure and dose rate conversion factors for portable survey gamma and beta-gamma meters, all survey and laboratory instruments were calibrated with NBS-traceable standards. The calibration procedures for these portable instruments are described above.

Quality control procedures on all instruments included daily background and check-source measurements to confirm equipment performance was within expected statistical fluctuations. The ORAU laboratory participates in the EPA Quality Assurance Program.

APPENDIX B

SUMMARY OF RADIATION GUIDELINES APPLICABLE TO OFF-SITE PROPERTIES AT THE NIAGARA FALLS STORAGE SITE

U. S. DEPARTMENT OF ENERGY

INTERIM RESIDUAL CONTAMINATION AND WASTE CONTROL GUIDELINES
FOR
FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM (FUSRAP)
AND
REMOTE SURPLUS FACILITIES MANAGEMENT PROGRAM (SFMP) SITES

(Review Within DOE Continuing)

Presented here are the residual contamination cleanup and waste control guidelines of general applicability to the FUSRAP project and remote SFMP sites[1/]. A site-specific analysis will be prepared for each FUSRAP and remote SFMP site prior to determining residual contamination guidelines for a specific site. In addition, it is the policy of the DOE to decontaminate sites in a manner consistent with DOE's as-low-as-reasonably-achievable (ALARA) policy. ALARA will be considered in reducing levels of residual contamination below applicable dose limits. ALARA will be implemented using cost/benefit considerations, and applied on a site-specific basis.

The soil residual contamination guidelines were developed on the basis of limiting maximum individual radiation exposure to DOE limits specified in DOE Order 5480.1A exclusive of exposure from natural background radiation or medical procedures. The radium-226 and thorium-230 guidelines include an additional limitation for buildup of radon-222 decay products in buildings. The aggregate of the contribution from all major pathways, based on scenarios for permanent intrusion, e.g., establishing residences on the site, was assumed. In most circumstances, the probability is low that such an intrusion will occur. Also, conservative assumptions were used in deriving these guidelines to ensure that a particular dose limit would not be exceeded. Use of these guidelines is additionally conservative because the pathways considered in the derivation of the guidelines assume all water intake and most food intake is from the site. Also, the FUSRAP and remote SFMP sites often have limited agricultural capability and the contamination is generally not homogeneous. The combined effect of these factors is such that the probable radiation exposure to the average population on, or in the vicinity of, FUSRAP or remote SFMP sites decontaminated to these guidelines will not be appreciably different from that normally received from natural background radiation.

The residual contamination guidelines for surface contamination of structures were adapted from guidelines developed by the U. S. Nuclear Regulatory Commission (NRC) for decontamination of facilities and equipment prior to release for unrestricted use or termination of licenses for byproduct, source, or special nuclear material[2/]. The waste control guidelines are consistent with applicable DOE Orders and EPA's regulations for inactive uranium milling sites, 40 CFR Part 192.

[1/] A remote SFMP site is one that is excess to DOE programmatic needs and is located outside a major operating DOE R&D or production area. Remote sites are more likely to be released to the public or excessed to other government agencies after decontamination than are sites located with major R&D or production areas.

2/ U. S. Nuclear Regulatory Commission 1982 Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material. Division of Fuel Cycle and Material Safety, Washington, DC.

A. RESIDUAL CONTAMINATION GUIDELINES FOR FORMERLY UTILIZED SITES AND REMOTE SURPLUS FACILITIES MANAGEMENT PROGRAM SITES

The following guidelines represent the maximum residual contamination limits for unrestricted use of land and structures contaminated with radionuclides related to the nuclear fuel cycle at FUSRAP and remote SFMP sites. A site-specific analysis will be prepared for each site prior to determining residual contamination guidelines for a specific site. It is the policy of DOE to decontaminate sites to contamination levels at or below the limits and in a manner consistent with DOE's as-low-as-is-reasonably-achievable (ALARA) policy on a site-specific basis. Site-specific guidelines and ALARA policy will be determined by DOE on a site-specific basis and an ALARA report filed on completion of remedial action at a site. Existing state and federal standards will be applied for water protection. Residual contamination limits for other nuclides will be developed when required using the same methodology[1/] as was used for those represented here.

1. Soil (Land) Guidelines (Maximum Limits for Unrestricted Use)

Radionuclide	Soil Criteria[2/,3/,4/] (pCi/g above background)
U-Natural[5/]	75
U-238[6/]	150
U-234[6/]	150
Th-230[7/]	15
Ra-226	5 pCi/g, averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over 15 cm thick soil layers more than 15 cm below the surface and less than 1.5m below the surface.
U-235[6/]	140
Pa-231	40
Ac-227	190
Th-232	15
Am-241	60
Pu-241[8/]	2400
Pu-238, 239, 240	300
Cs-137	80

Sr-90	300
H-3 (pCi/ml soil moisture)	5,200

1/ Described in ORO-831 and ORO-832.

2/ In the event of occurrence of mixtures of radionuclides, the fraction contributed by each radionuclide to its guideline shall be determined, and the sum of these fractions shall not exceed 1. There are two special cases for which this rule must be modified:

(a) If Ra-226 is present, then the fraction for Ra-226 should not be included in the sum if the Ra-226 concentration is less than or equal to the Th-230 concentration. If the Ra-226 concentration exceeds the Th-230 concentration, then the sum shall be evaluated by replacing the Ra-226 concentration by the difference between the Ra-226 and Th-230 concentrations.

(b) If Ac-227 is present, then the same rule given in (a) for Ra-226 relative to Th-230 applies for Ac-227 relative to Pa-231.

3/ Except for Ra-226, these guidelines represent unrestricted-use residual concentrations above background averaged across any 15 cm thick layer to any depth and over any contiguous 100 m^2 surface area. The same conditions prevail for Ra-226 except for soil layers beneath 1.5 m; beneath 1.5 m, the allowable Ra-226 concentration may be affected by site-specific conditions and must be evaluated accordingly.

4/ Localized concentrations in excess of these guidelines are allowable provided that the average over 100 m^2 is not exceeded. However, DOE ALARA policy will be considered on a site-specific basis when dealing with elevated localized concentrations.

5/ A curie of natural uranium means the sum of 3.7×10^{10} disintegrations per second (dis/s) over any 15cm thick layers from U-238 plus 3.7×10^{10} dis/s from U-234 plus 1.7×10^{9} dis/s from U-235. One curie of natural uranium is equivalent to 3,000 kilograms or 6,600 pounds of natural uranium.

6/ Assumes no other uranium isotopes are present.

7/ The Th-230 guideline is 15 pCi/g to account for ingrowth of Ra-226 as Th-230 decays. Ra-226 is a limiting radionuclide because its decay product is Rn-222 gas.

8/ The Pu-241 guideline was derived from the Am-241 concentration.

2. Structure Guidelines (Maximum Limits for Unrestricted Use)

a. Indoor Radon Decay Products

A structure located on private property and intended for unrestricted use shall be subject to remedial action as necessary to ensure the annual average concentration of radon decay products is less than 0.03 WL within the structure.

b. Indoor Gamma Radiation

The indoor gamma radiation after decontamination shall not exceed 20 microroentgen per hour (20 R/h) above background in any occupied or habitable building.

c. Indoor/Outdoor Structure Surface Contamination

Radionuclides 2/	Allowable Surface Residual Contamination 1/ (dpm/100 cm^2) Average 3/,4/	Maximum 4/,5/	Removable 4/,6/
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	300	20
U-Natural, Th-232, Sr-90, Fr-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay products	5,000	15,000	1,000
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000	15,000	1,000

1/ As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

2/ Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides shall apply independently.

3/ Measurements of average contaminant should not be averaged over more than 1 m^2. For objects of less surface area, the average shall be derived for each such object.

4/ The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h at 1 cm and 1.0 mrad/h at 1 cm, respectively, measured through not more than 7 mg/cm^2 of total absorber.

5/ The maximum contamination level applies to an area of not more than 100 cm^2.

6/ The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels shall be reduced proportionately and the entire surface shall be wiped.

B. CONTROL OF RADIOACTIVE WASTES AND RESIDUES FROM FUSRAP AND REMOTE SFMP SITES

Specified here are the control requirements for radioactive wastes and residues related to the nuclear fuel cycle at FUSRAP and remote SFMP sites. It is the policy of DOE to store radioactive wastes in a manner representing sound engineering practices consistent with DOE's ALARA policy.

1. Interim Storage

All operational and control requirements specified in the following DOE Orders and other items shall apply:

a. 5480.1A, Environmental Protection, Safety, and Health Protection Program for DOE Operations.

b. 5480.2, Hazardous and Radioactive Mixed Waste Management.

c. 5483.1, Occupational Safety and Health Program for Government-Owned Contractor-Operated Facilities.

d. 5484.1, Environmental Protection, Safety, and Health Protection Information Reporting Requirements.

e. 5484.2, Unusual Occurrence Reporting System.

f. 5820, Radioactive Waste Management.

g. Control and stabilization features will be designed to ensure, to the extent reasonably achievable, an effective life of 50 years, and in any case, at least 25 years.

h. Rn-222 concentrations in the atmosphere above facility surfaces or openings shall not (1) exceed 100 pCi/l at any given point, or an average concentration of 30 pCi/l for the facility site, or (2) exceed an average Rn-222 concentration at or above any location outside the facility site of 3.0 pCi/l (above background).

i. For water protection, use existing state and federal standards; apply site-specific measures where needed.

2. Long-Term Management

a. All operational requirements specified for Interim Storage Facilities (B.1) will apply.

b. Control and stabilization features will be designed to ensure to the extent reasonably achievable, an effective life of 1,000 years and, in any case, at least 200 years. Other disposal site design features shall conform with 40 CFR Part 192 performance guidelines/requirements.

c. Rn-222 emanation to the atmosphere from facility surfaces or opening shall not (1) exceed an average release rate of 20 $pCi/m^2/s$, or (2) increase the annual average Rn-222 concentration at or above any location outside the facility site by more than 0.5 pCi/l.

d. For water protection, use existing state and federal standards; apply site-specific measures where needed.

e. Prior to placement of any potentially biodegradable contaminated wastes in a Long-Term Management Facility, such wastes will be properly conditioned to (1) ensure that the generation and escape of biogenic gases will not cause the requirement in paragraph 2.c. to be exceeded, and (2) ensure that biodegradation within the facility will not result in premature structural failure not in accordance with the requirements in paragraph 2.b.. If biodegradable wastes are conditioned by incineration, incineration operations will be carried out in compliance with all applicable federal, state, and local air emission standards and requirements, including any standards for radionuclides established pursuant to 40 CFR Part 61, National Emission Standards for Hazardous Air Pollutants (NESHAPS).

C. EXCEPTIONS

Exceptions may be made to the guidelines presented herein following analysis of the site-specific aspects of a candidate site. Specific situations that warrant consideration for modifying these guidelines are:

1. Where remedial actions would pose a clear and present risk of injury to workers or members of the public, notwithstanding reasonable measures to avoid or reduce risk.

2. Where remedial actions would produce environmental harm that is clearly excessive compared to the health benefits to persons living on or near affected sites, now or in the future, notwithstanding reasonable measures to limit damage to the environment. A clear excess of environmental harm is harm that is long-term, manifest, and grossly disproportionate to health benefits that may reasonably be anticipated.

3. Where the cost of remedial actions for contaminated soil is unreasonably high relative to long-term benefits and the residual radioactive materials do not pose a clear present or future hazard. The likelihood that buildings will be erected or that people will spend long periods of time at such a site should be considered in evaluating this hazard. Remedial actions will generally not be necessary where residual radioactive materials have been placed semipermanently in a location where site-specific factors limit their hazard and from which they are costly or difficult to remove, or where only minor quantities of residual radioactive materials are involved. Examples are residual radioactive materials under hard surface public roads and sidewalks, around public sewer lines, or in fence-post foundations. Supplemental standards shall not be applied at such sites, however, if individuals are likely to be exposed for long periods of time to radiation from such materials at levels above those that would prevail in Subpart A.

4. Where the cost of cleanup of a contaminated building is clearly unreasonably high relative to the benefits. Factors that shall be included in this judgment are the anticipated period of occupancy, the incremental radiation level that would be affected by remedial actions, the residual useful lifetime of the building, the potential for future construction at the site, and the applicability of less costly remedial methods than removal of residual radioactive materials.

5. Where there is no known remedial action.

D. GUIDELINE SOURCE

Guideline	Source
Residual Contamination Criteria[1/]	
Soil Guideline	DOE Order 5480.1A, 40 CFR Part 192[2/]
Structure Guideline	40 CFR Part 192, NRC Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material (July 1982).
Control of Radioactive Wastes and Residues	
Interim Storage	DOE Order 5480.1A
Long-Term Management	40 CFR Part 192

[1]/The bases of the residual contamination guidelines are developed in ORO-831 and ORO-832.

[2]/Based on limiting the concentration of Ra-222 decay products to 0.03 WL within structures.